POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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WE DO OUR PART

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SEPTEMBER
1934

Vol. XXXVIII., No. 9

Published on the first of each month, copyright 1934 by the
Technical Publishing Co., 53 W. Jackson Blvd., Chicago.
New York Office, 171 Madison Ave.

EDITORIAL STAFF: ARTHUR L. RICE, Editor. R. E. TURNER, Managing Editor.
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Subscription price. U. S. A. $2.00 a year; other countries, $3.50 a year. Single copy current issue, 25c; other countries, 35c. January 1 issue, U. S. A., 50c; other countries, 60c. Back issues, single copy, U. S. A., 40c; other countries, 50c. January 1 issue, U. S. A., 75c; other countries, 85c.

Member, Associated Business Papers, Audit Bureau of Circulations.
Circulation of this issue 19,900

The THORS *of Pittsfield*

Engineers at the General Electric Co. Lightning Research Laboratory Watching High Current Discharge.

THOUGH WE HAVE never seen statistics regarding the relative number of thunder storms in various sections of the country, we would like to wager that Pittsfield, Massachusetts, is the scene of more lightning strokes than any other place in the country. For it is a known fact that in Pittsfield they don't just wait for lightning, they make it; indeed, the manufacture of lightning has become one of the town's chief industries. Started in a small way by Steinmetz many years ago, the business has expanded enormously. Each year the quality of the product has improved until today the bolts they turn out rival those produced by old Thor himself. Within the past few weeks, in fact, these modern Thors of Pittsfield have produced bolts that exceed the current values of any direct stroke of lightning ever measured—a discharge of approximately a quarter of a million amperes! In the photograph shown here you see five of these modern Thors watching the production of one of these high current discharges. When Thor, Jr., at the right pushes the button, some thirty million kilowatts of electrical energy will be released with a crash that rivals the discharge of a big gun. See page 424.

Of a different quality but none the less effective is the chained lightning contained in the 100,000 gallons of whiskey which constitutes one day's output of the new Hiram Walker distillery at Peoria, Ill. Government inspection, however, renders even this huge quantity of firewater quite safe: every valve, every flanged joint is sealed and every drop of liquor must be accounted for. The processes are under the eagle eyes of almost a hundred government inspectors. Indeed the whole thing proved quite a disappointment to the editor who went down there from Power Plant Engineering to write the article on the plant which appears in this issue. Though he got a splendid article, he came back just as dry as when he went and the temperature, mind you, was several degrees above a hundred in the shade and there was no shade.

Aside from that, however, this distillery, said to be the world's largest, is unusually interesting and impressive, and it was built in record time. The engineering features of the power plant serving this distillery are described in this issue. A more detailed description of the distilling processes and methods of power utilization will appear in the October issue.

The life of an editor is not an easy one despite general opinion to the contrary. We have already mentioned the Hiram Walker incident. That was difficult enough in itself but now imagine the editor's lot on a hot summer's day when he finds it necessary to write an article on heating! But he bears his lot patiently and the article on page 412 on the general subject of heating shows little evidence of the high temperature conditions under which it was prepared. Much work has been done in recent years in formulating data on heating and this article which discusses the application of such data should be of value to anybody contemplating changes or extensions in his heating plant.

Among those who read these lines there may be a few who are inclined to doubt the truth of our statement about the editor's hard lot, particularly if such readers spend much of their time in the boiler room. Well, perhaps they are correct and they certainly have a right to their opinion, but at the same time we can imagine no "softer" job than to be engineer in a boiler plant such as is described on page 427. About the hardest thing such an engineer would have to do, it seems to us, would be to take his feet off the desk and call up a cleaning establishment to have his white suit cleaned and pressed about once a month. We have read this article over a dozen times or more but so far we haven't been able to discover anything for an engineer to do in a plant equipped with such boilers. Whenever more such units are installed our application will be in—it sure would be "the life of Riley." "More power to gas" is our motto.

With the Editors

Trade Associations and the Codes

ALTHOUGH THERE is room for considerable differences of opinion as to the advisability of some of the provisions of the various codes, the principle of doing away with unfair and injurious trade practices will receive the endorsement of most manufacturers. Present indications seem to point to the turning over of such provisions as deal with unfair practice to the trade associations for administration, hence it would seem wise policy for the associations to perfect their organizations so as to provide for this activity.

If unfair practice is to be abolished, the interests of the smaller as well as the larger members of the associations must be safeguarded. Regulations should be so drawn and enforcing agencies so set up that fair but active competition will be ensured, with adequate, enforceable penalties against any members, large or small, who indulge in unfair, or destructive competition.

Unquestionably, trade organizations, well organized and in close touch with trade conditions can do a better job of formulation and administration of such regulations than a government agency, which is by its nature politically minded to a large extent. But the trade associations must be strong, representative of their industries, interested in the welfare of all members and harmonious in operation. Unless an association is really representative of the industry, is free from internal strife and is conducted for the welfare of all members with due regard to the interests of the public it is unlikely to be of benefit to the industry or to the community.

Leaders who are endeavoring to build and improve trade associations along the necessary lines, deserve the support of their industries to the end that the associations be adequately prepared to take over administration of such desirable provisions of the codes as the government may shortly turn over to them.

A Condenser Which Passes Direct Current

STRANGE ARE the ways of high frequency currents. In one instance they will refuse to stay on the conductors intended to carry them and jump off through space as effectively as though through solid connections, yet in another instance they refuse to go through a virtual short circuit. To those who are versed only in the electrical theory of pre-war days, these currents seem all haywire, obeying no laws and violating all the established principles of classical electrical engineering.

And yet, to the young radio engineer of today these currents are as docile and as subject to calculation and control as are ordinary direct and low frequency alternating currents. His familiarity with them is astonishing in view of what was known even ten years ago and daily he is finding new applications and new circuits for them. Among the more recent of his achievements in this field is a condenser that will pass direct current!

Now, to most of us, this is quite startling for our usual conception of a condenser is an arrangement of two conducting surfaces separated by an insulating medium, and even by the wildest stretch of one's imagination we cannot conceive of direct current passing through such an arrangement. And in this belief we are quite correct. The ordinary condenser is an effective barrier to direct current.

The new form of condenser we have reference to here is quite different from the orthodox form with which we are familiar. This condenser, in fact, is nothing more than a two wire transmission line closed at the distant end and of such length as to be resonant with the frequencies for which it is designed. The effectiveness of such an arrangement is a function of the frequency—the higher the frequency the better it works. At frequencies of the order of 28 megacycles it is a simple matter to obtain resonant impedances in excess of 100,000 ohms. By arranging such transmission lines either as open or closed circuits they act either as inductive or capacitive reactances. It is in the latter instance that we have a condenser which at the same time passes direct current.

Such resonant lines have many applications not only in radio work but anywhere where high frequency currents are useful. They are made very simply either in the form of two parallel wires or of two concentric tubes. In the latter case they may be made in the form of a flexible cable which may be coiled up in a very small space.

Thus the established principle of resonance leads to another new device which opens up a new field of development in electrical engineering. Circuits of this type are not only useful as condensers but also as amplifier circuits, filters, means of frequency control and coupling devices. Their use in the power field may be limited but the theory of their operation is a matter in which electrical engineers generally will be interested.

ESTIMATED additional generating capacity needed of 4,200,000 kw-hr. by the fall of 1935 is noted in a bulletin of the National Electrical Manufacturers Assn., based on a statistical survey of present load building results and estimated new load that has been added since 1929. New load added during the upturn in business is expected to be greater than that lost during the downward trend. The bulletin states, "Between constantly increasing load, new appliances and power consuming devices, it looks as if the electrical manufacturing industry can take heart and look forward."

The World's Largest Distillery-

Fig. 1. The new Hiram Walker distillery at Peoria showing the power plant centrally located among the many steam using buildings

FOR THREE QUARTERS of a century Hiram Walker & Sons, Inc., has played an important role in the distilling industry. From the beginning at Walkerville, Ont., in 1858, the company has grown to leadership in the field, known throughout the world for the quality of its liquors, its integrity and progressiveness. Certain it is that the position has been well earned and that the new distillery at Peoria, Ill., "The Largest Distillery in the World," sets new standards of quality, quantity and efficiency, made possible only by taking advantage of continuous and automatic operation and the latest advances in mechanical, electrical and chemical engineering.

Built to make rye and bourbon whiskies, high proof spirits and gin with fusel oil, dried grains and denaturing grade alcohol as by-products, the plant at capacity will mash 20,000 bu. of grain and distill 100,000 gal. of whisky per day of 24 hr., or, using only part of the equipment as present government regulations prohibit both being made at the same time, 50,000 gal. of high proof spirits.

Equally impressive is the construction record established. In September, 1933, the 20 a. site was bare of all but weeds. Excavation was started early in that month, concrete pouring started a few days later and by June, 1934, whisky was being made. The formal opening on July 4 attracted some 75,000 visitors. Now, less than a year after construction work started, the distillery is complete, with lawns in and driveways paved, making what is perhaps the most impressive group of industrial buildings in America today. Both architecturally and technically the new plant is a tribute to Smith, Hinchman & Grylls, architects and engineers, and H. F. Wilkie, vice-president of production, who, with his technical staff, coöperated in the design from a background of many years' distillery operation.

Steam Load

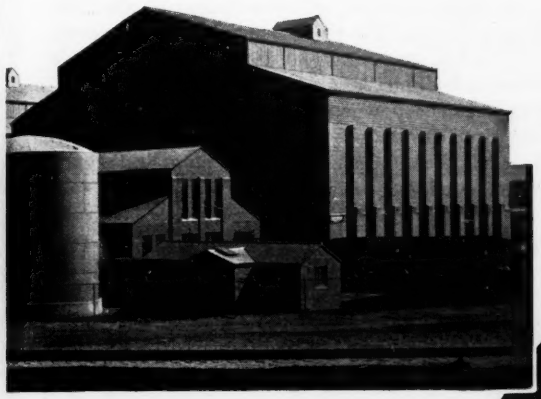
Naturally adequate power plant facilities form an important part of a modern industrial establishment of this size and type which uses, on the average, 2800 kw. of electricity, 240,000 lb. per hr. of steam and 4000 g.p.m. of cold well water. Contrary to past American distillery practice, steam driven process auxiliaries have been eliminated and motor drives used throughout.

This simplifies the steam piping layout, gives a higher ratio of power generation by high efficiency turbo-generators and gives a better steam and power balance. Steam used in the various departments is shown by Table I. The first three departments listed use 70 lb. steam extracted from the turbines, the balance, with the exception of small quantities in the miscellaneous classification, use 15 lb. steam exhaust from the turbines. In an emergency the average load of 240,000 lb. per hr. can be reduced to 180,000 lb. without spoilage in process.

Cold water is used in the process, principally for

—Hiram Walker & Sons, Inc. Peoria, Illinois

Built in Less than a Year, This Distillery Turns Out 100,000 Gal. of Whisky a Day. The Power Plant Which Burns 350 t. of Coal a Day Has Two 180,000 lb. per hr. Pulverized Coal Fired Boilers and Two 1500 kw. Turbo-Generators Operating in Parallel with the Utility System on a Power Interchange Agreement



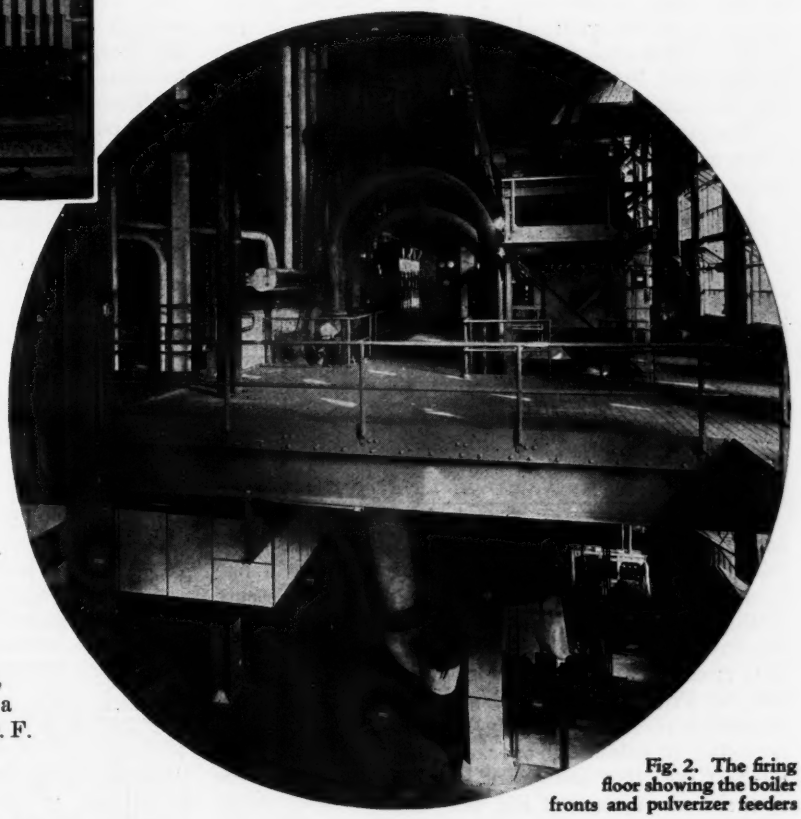


Fig. 2. The firing floor showing the boiler fronts and pulverizer feeders

cooling the mash, maintaining the fermenters at constant temperature and for the still condensers. Heat conservation has been carefully considered and the cooling water, heated to from 140 to 180 deg. F. is stored for use in the cookers and for boiler feed make-up. Peoria has long been an important center of the American distillery industry, due largely to its proximity to the grain growing districts and to an abundance of suitable well water, high in carbonate hardness, with a moderate lift and flowing at a constant temperature of about 53 deg. F. throughout the year.

The Distillery

As the power facilities were designed to serve this particular distillery, at least a superficial knowledge of the production process is advisable in order to appreciate fully the reasons for certain power plant details[1]. Briefly, the grains are ground to meal, mixed in the desired proportions, cooked with steam and the resulting mash cooled and fermented at constant temperature for 72 hr. and then distilled. The resulting whisky may be stored a short time in the high wines building or may be pumped direct to the shipping and cistern building where it is proofed or mixed with distilled water to bring it to the desired strength before barrelling. Whisky is then stored in charred oak barrels in bonded warehouses for at least 4 yr. Alcohol

[1] A more detailed description of the distilling process will appear in the October issue.

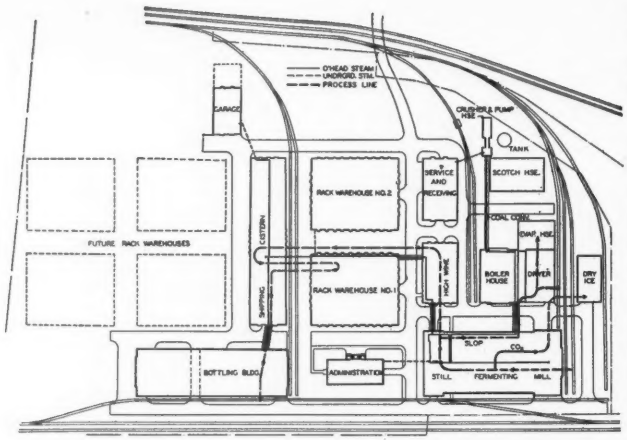


Fig. 3. Plan of the distillery showing the heating system piping and the course of the product from grain to bottle

and gin may be bottled immediately without aging.

Names of the buildings are given on the plan, Fig. 3, which also indicates by means of heavy dashed lines the course of the grains and whisky through the plant, on what an industrial engineer might term straight line production. The raw product, grain, comes in on the railroad, goes directly through the plant without doubling on its course, the finished product and by-products ending up on the railroad. The flow diagram, Fig. 4, shows the complete process.

The power house, a six-story building built without a basement and measuring 96 by 108 ft., is located in the center of the main steam-using group, the natural

Table I.
Approximate Steam Requirements for Process

Cookers	28,000 lb. per hr.
Yeast mash tubs	2,000 lb. per hr.
Dryers	17,000 lb. per hr.
2 bourbon whisky stills	26,000 lb. per hr.
2 continuous stills	45,000 lb. per hr.
Charge still	26,000 lb. per hr.
Building heating	20,000 lb. per hr.
Water heating	25,000 lb. per hr.
Condensate loss and miscellaneous	51,000 lb. per hr.
	240,000 lb. per hr.
Normal flow	240,000 lb. per hr.
Maximum flow	300,000 lb. per hr.
Min. emergency flow to avoid loss of material in process	180,000 lb. per hr.

advantages of the site with railroad tracks on three sides, being used to full advantage. The central bay of the boiler room was built 116 ft. high, to take care of the breechings which lead to the single steel stack supported on the building steelwork. This stack, 12 ft. I.D., rises 153 ft. above the base or 229 ft. above the ashpits. Practically all piping, both steam and water, is located in a pipe gallery back of the boilers and immediately below the operating floor. The arrangement of the other equipment is evident from a glance at the cross sections of Fig. 5.

Future Equipment

Although space has been provided in the building for a third boiler, it is questionable if it will ever be installed due to special operating conditions which appear to make standby equipment unnecessary. In the first place, government regulations prevent operation on Sunday so the distillery is closed down at 11 P. M. Saturday and started up at 1 A. M. Monday. With pulverized coal allowing quick cooling of the furnace, it is thought that this period, allowing each boiler to be taken off the line once every two weeks, will be sufficient for minor repairs. In the second place, it is the practice of the company to shut down the distillery for a more or less extended period each year and this shut down will give sufficient time for more extensive repairs that may be necessary. Extensive boiler outage at other times would of course mean curtailed production but a turbine outage would simply mean purchasing more power and supplying process steam through reducing valves. Space has also been provided in the plant for a third turbo-generator, probably a double extraction condensing unit which will be installed as soon as final load requirements and definite steam-power balance are determined from actual operation.

From the track hopper coal is elevated to the 2000 t. bunker by a Robins 75 t. per hr. belt conveyor system consisting of a reciprocating feeder, 20 by 34 in. double roll crusher, a 30 and 24 in. belt and a belt tripper. The conveyor to the power plant is covered by a housing of Robinson protected metal with a walkway on each side and access doors at convenient intervals. This housing conforms in design to the bridges connecting the various buildings which although simple, has been well handled, giving a cheap and attractive solution to one of the most trying architectural problems.

Outside storage has been eliminated by the unusu-

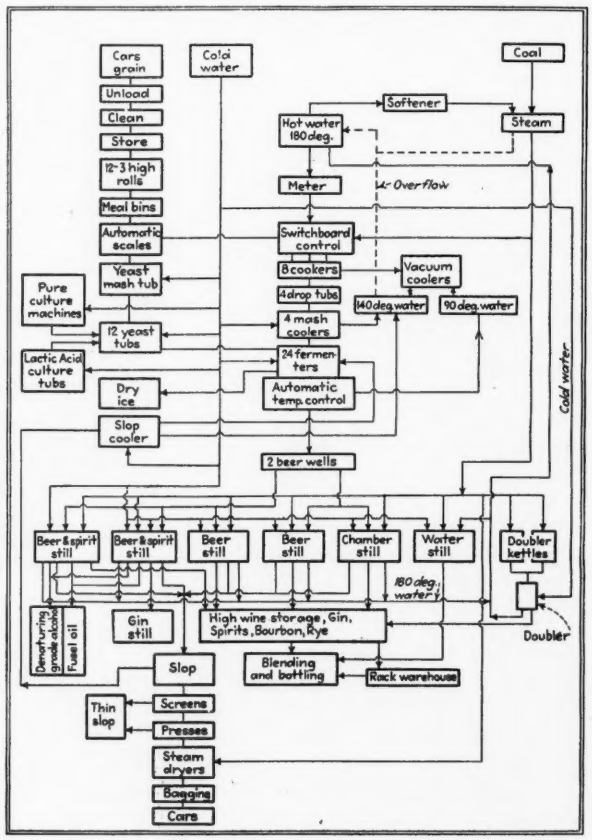


Fig. 4. Flow sheet of the distillery

ally large bunker holding about a week's supply of coal which, with the plant located close to the coal fields, it was felt gave sufficient storage. At present a local slack running about 9600 B.t.u., 15.75 per cent moisture, 2.50 per cent sulphur and 15 per cent ash with a softening temperature of 2000 deg. F. is being burned although with the crusher, run of mine with lumps up to 14 in. can be handled.

From the bunker the coal passes through Richardson automatic scales to the pulverizers located on the first floor. Due to the necessity for a large bunker the depth was increased to such an extent that the three gates, directly above the scales and pulverizer feeders, will not entirely empty it. To make this possible, heated by Aerofin steam heaters. The large mills fire their respective boiler through two burners and the small mill fires either boiler through a smaller burner located between and slightly lower than the main burners.

The two boilers are 1879 hp. Stirlings with a normal capacity of 150,000 lb. per hr. of steam or a maximum capacity of 180,000 lb. for two hours. Boiler settings are steel encased, each boiler having 7430 cu. ft. furnace with 2246 sq. ft. of water cooled surface made up of stud tube downtake and side walls, baretube uptake wall and Bailey block hopper walls. All brickwork except the rear wall and a small area in the front is of Bigelow-Liptak suspended wall construction. Ash hop-

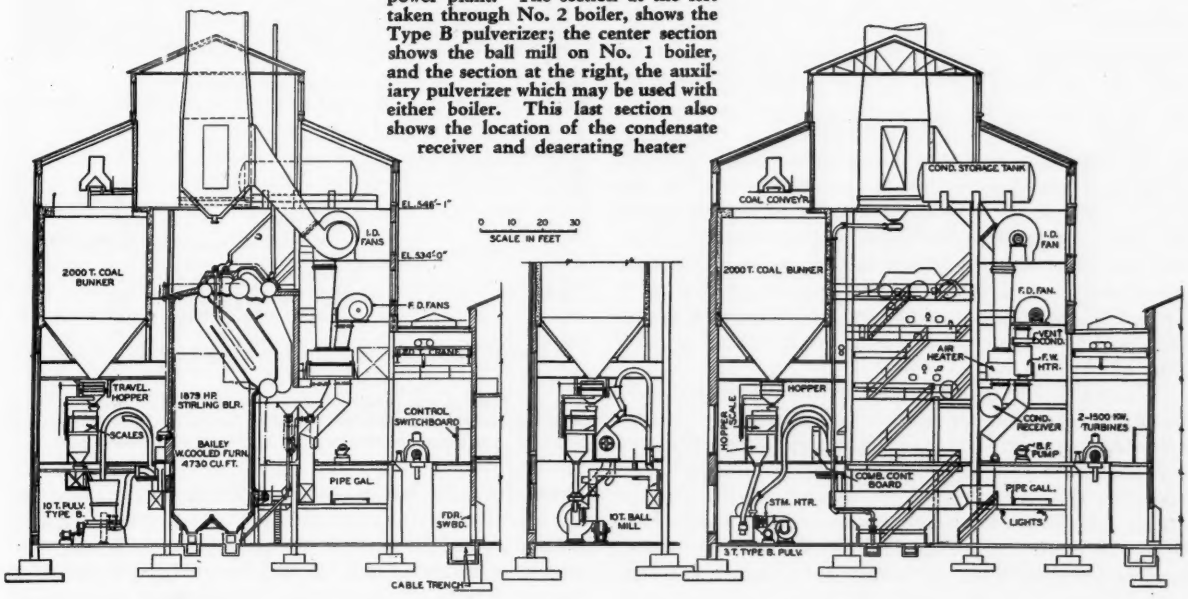


Fig. 5. Cross sections through the power plant. The section at the left taken through No. 2 boiler, shows the Type B pulverizer; the center section shows the ball mill on No. 1 boiler, and the section at the right, the auxiliary pulverizer which may be used with either boiler. This last section also shows the location of the condensate receiver and deaerating heater

primarily in case of fires expected with the bituminous coal used, extra gates were added and these gates can be reached by 3 t. traveling hoppers or larries operated from the feeder level by push button control.

Three pulverizers, a 10 t. Kennedy-Van Saun ball mill, a 10 t. B & W type B, and a 3 t. B & W type B, were installed. Different types of main pulverizers were used because of the different operating characteristics of the two types. The ball mill, which fires No. 1 boiler, has a low power unit consumption at full load but the power consumption remains practically constant over the entire load range while with the roller mill, which fires No. 2 boiler, the power consumption is more nearly proportional to the load. For this reason No. 1 boiler will be operated at a constant full load with the swings carried by No. 2 so as to give the lowest total pulverizer power consumption.

A small 3 t. B & W type B pulverizer is installed between the two large ones piped so that it can be used for either mill. It was intended primarily to carry light loads during week ends or to assist the large pulverizers when the boilers were developing maximum capacity but since the design was completed, a natural gas connection has been added to answer the same purpose. Primary air through this small mill is pers with double gates and with the longitudinal axes at right angles to the railroad track were used. This construction made necessary by the shape of the furnace and the fact that the plant had no basement, introduced a difficult problem of ash disposal which was solved in an ingenious way by a movable conveyor. Two flight conveyors which run beneath the boilers, as shown by Fig. 7, could not discharge through the end of the building due to the proximity of the evaporator house. A cross conveyor was provided, but as it was impossible to get sufficient height to clear a box car passing on the adjacent track, this cross conveyor was made movable. Extended, it will hang over the track for filling cars; partially withdrawn, it will allow any type of car to pass on the track or, completely withdrawn, it can be used for loading trucks parked in the doorway. Soot and dust from the back of the boiler breeching and stack is handled by an Allen-Sherman-Hoff vacuum system which discharges to the ash conveyor.

Boilers, set high to provide ample furnace volume without excavation, are baffled for three passes and have Sturtevant forced and induced draft fans. Ljungström air heaters, Bailey meters, Bailey combustion control, Diamond soot blowers, and a Hays CO_2

recorder on the master control panel. Arrangement of the boiler unit and auxiliaries is shown by the cross sections, Fig. 5. Induced draft fans, one for each boiler, each with a capacity of 230,000 lb. per hr. of flue gases at 6.5 in. and 440 deg. F. when driven at a maximum speed of 884 r.p.m. by Westinghouse 250 hp. motors, are located on the fifth floor of the power plant and discharge to the stack through a short breeching.

Forced draft fans, also one for each boiler, each with a capacity of 175,000 lb. of air per hr. at 8 in. and 100 deg. F. when driven at the maximum speed of 1175 by 25 hp. Westinghouse motors, are located on the floor below the induced draft fans. They discharge downward through the air heater on the floor below to the burners. Each boiler has three burners, two for the main pulverizer and one for the auxiliary pulverizer. On No. 2 boiler all three are B & W combination burners for gas or coal, while on No. 1 boiler only the auxiliary burner is of the combination type.

Automatic Pilot Light

For ignition purposes an automatically operated pilot light arrangement is used. As soon as the gas valve to the burners is opened, the gas flowing across an orifice installed in the line, operates a General Electric diaphragm switch which in turn opens a Ruggles-Klingemann electrically operated valve in the pilot line. The pilot light, ignited by a high tension spark, remains lighted as long as gas is being burned or until shut off by hand.

Control of the boilers under normal operation is by Bailey automatic air-operated combustion control, actuated primarily by the main steam pressure and regulating the speed of the forced draft, induced draft and coal feeder motors. A secondary control through an air-flow steam-flow meter actuates the master controller to maintain the air fuel ratio. A Bailey master control panel with an operating control panel for each boiler is provided, arranged so as to facilitate a change from automatic to manual operation or back again. In addition to the combustion control switches and indicators the boiler panels have a pressure gage, water level indicator, five pointer draft gage, steam flow meter with water level and feedwater temperature pens, boiler meter with a steam temperature pen and a four pen recording thermometer for the air and gases entering and leaving the air heater.

No Wall Between Boilers and Turbines

Two boiler feed pumps, each large enough to supply both boilers at maximum load, are located directly

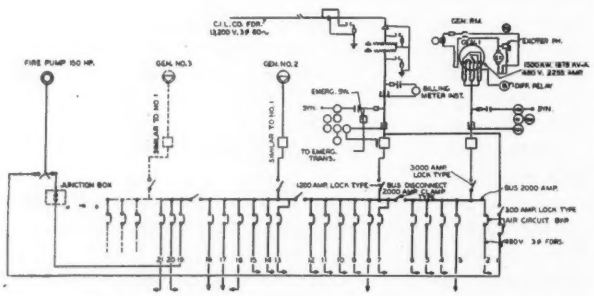


Fig. 6. Single line wiring diagram of the generator and switchboard

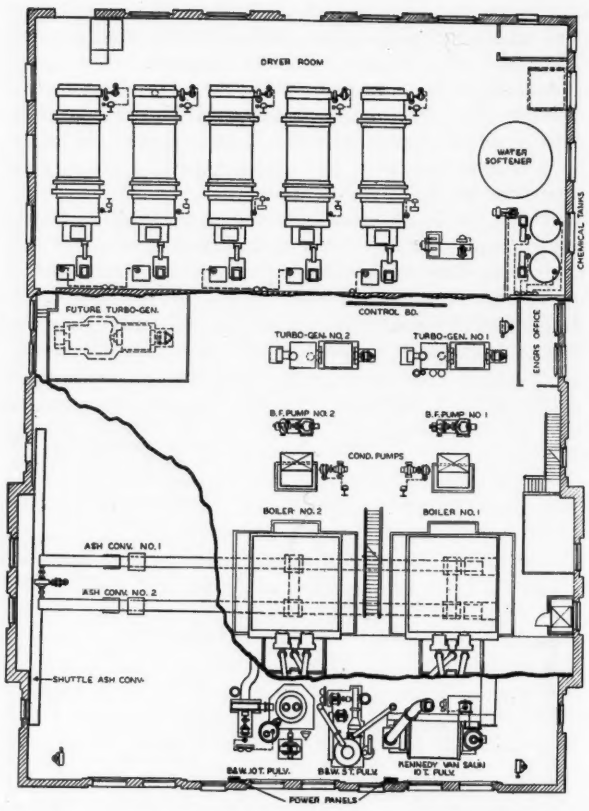


Fig. 7. Plan of the power plant. The second or operating floor with the boilers and turbines is shown inside of the broken line; the balance of the plan is the ground floor

back of the boilers on the operating floor. They are De Laval centrifugal units rated at 600 g.p.m. against a head of 860 ft. and driven at 3000 r.p.m. by 170 hp. turbines taking steam at boiler conditions and discharging to the 15 lb. system. Each pump is equipped with a governor and relief valve and feeds the boilers through Swartwout constant pressure differential valves and feedwater regulators.

No curtain wall is provided between the boiler and turbine rooms, the turbo-generators being located on the operating floor in a bay just behind the boiler feed pumps. This bay, lower than the boiler room, has a 20 t. Whiting crane to facilitate installation and maintenance. Two General Electric 1500 kw., 3660 r.p.m. units, designed to take steam at 230 lb., 100 deg. superheat, bleed at 75 lb. ga. and exhaust at 15 lb. ga. each drives an 1875 kv-a., 80 p.f., 480 v., 3 ph. 60 cycle generator and a direct connected exciter. Generators are equipped with differential relay protection not commonly used on machines of this size, the connections being shown on the single line diagram, Fig. 6. Normally both generators will be operated in parallel with the Central Illinois Light Co., on a power interchange agreement, through a bank of three 333 kv-a., 13,200/460 v., O.I.S.C. transformers and a 13,200 v. underground line, although the two generators, or one generator and the incoming line, will carry the plant load.

The control or operating panel located on the generator floor, is of the stretcher leveled steel panel type on which all instruments and control devices are

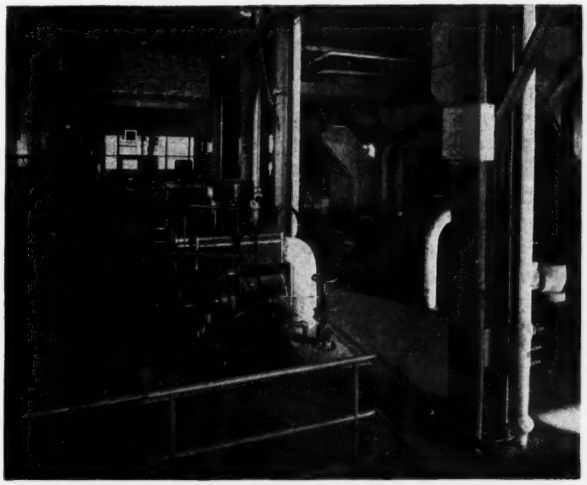


Fig. 8. Two 1500-kw. turbines operated in parallel with the utility system. The turbine driven boiler feed pumps are in the foreground

located. Directly underneath is the main switchboard which consists of 21 feeder panels, 2 generator panels and one incoming line panel. Three pole carbon air breakers are used on the feeders and oil breakers on the generator and incoming line service. All breakers are solenoid operated with closing current taken from a group of Rectox rectifying units and tripping current from a Philco storage battery. Both boards with instruments, breakers and synchronizing equipment were supplied by Westinghouse.

All motors of ¼ hp. and over are operated at 460 v. on power distributed over a 460 v., 3 ph. lead cable carried through fiber ducts to the service points in the several buildings on the property. Lighting transformer stations are placed at suitable locations for the 115/230 v. single phase three wire lighting system. Size and numbers of feeders to the various departments are given in Table II.

The steam cycle which can be traced from the steam piping diagram, Fig. 9, is simple but extremely flexible. Each boiler lead is connected to a cross which supplies directly its own turbines and auxiliaries. Although these fittings are cross connected by the 240 lb. header, the two sections of the plant can be separated and each operated as a unit. The 70 lb. system is normally supplied by automatic extraction from the main turbine but is connected to the 240 lb. system through two Swartwout reducing valves and desuperheaters, one automatically and one manually operated. The 15 lb. system, normally supplied from the boiler feed pump and main turbine exhaust, is also connected to the 70 lb. system by two reducing valves, one automatically and one manually operated, but without desuperheaters. Both the 15 and 70 lb. lines cross a pipe bridge to the fermenter house with no intervening valves but with relief valves at the other end. This is necessary because with certain conditions of operation with purchased power, the relief valves at the power house might be cut off from the mill pipe system.

About half of the normal boiler feed of 240,000 lb. per hr. is condensate returns, about equally divided between the 15 and 70 lb. system. The 70 lb. system returns having been kept under pressure are assumed to be air free and are returned directly to the receivers as shown by the water piping diagram Fig. 11. The 15 lb. returns being contaminated by air, flow through a Cochrane deaerating heater with a vent condenser before passing to the receiver. From the receiver the condensate is pumped by one of two 250 g.p.m. De Laval pumps to two 9 ft. dia. by 24 ft. long condensate storage tanks on the top floor above the induced draft fans. These tanks, tied together, and operated as a unit, overflow to the sewer.

Feedwater heater, receiver and condensate tanks are all under 15 lb. pressure. The receiver is kept drained by the two pumps mentioned above under control of four R-K float controls. One set of these floats, a normal high and low, control one pump, and the other set, with the high float set a little higher, control the second pump and ring an alarm. As one pump is large enough to handle the normal load with the second pump operating in an emergency only, a double pole

Table II.
Distribution of Load and Size of Feeders

1.	3—200 amp. feeders for 3—150 hp. well pump motors
2.	1—600 amp. feeder for dry-ice plant
3.	1—600 amp. feeder for scotch house
4.	1—600 amp. feeder for crusher house
5.	3—600 amp. feeders for mill building
6.	3—600 amp. feeders for power house
7.	1—300 amp. feeder for power house
8.	1—300 amp. feeder for dryer building
9.	1—600 amp. feeder for still building
10.	1—600 amp. feeder for bottling building
11.	1—300 amp. feeder for administration building
12.	1—200 amp. feeder for cistern, shipping building in garage
13.	1—200 amp. feeder for high wines and receiving building
14.	1—300 amp. feeder for two rack warehouses
15.	1—200 amp. feeder for fermenter building

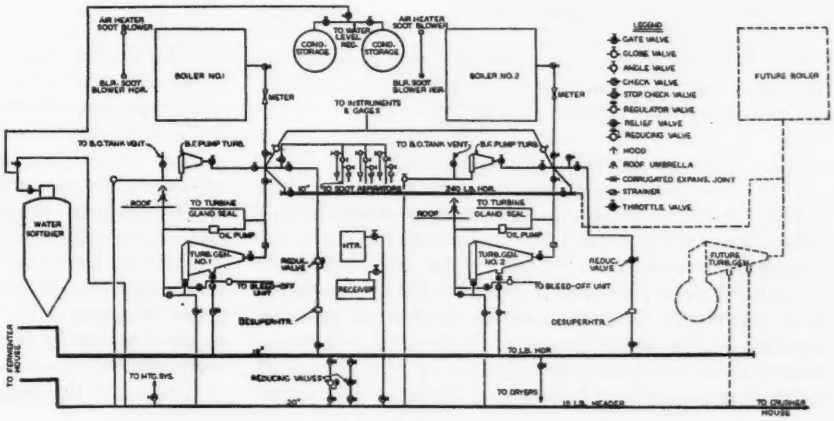


Fig. 9. Steam piping diagram. Practically all piping both steam and water is in a pipe gallery behind the boilers and just below the operating floor

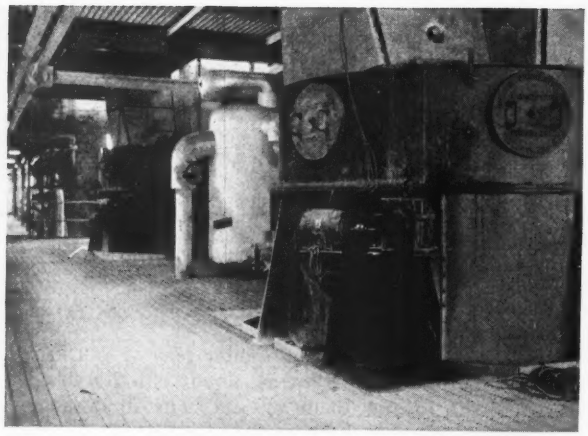


Fig. 10. The third floor showing the deaerating heater between the air heaters and, at the left, the entrance to the pipe bridge to the fermenter house

double throw switch is provided to change the float control connections and operate the pumps alternately week by week.

Water requirements not met by condensate are provided by excess process water which overflows from a storage tank in the cooker house. This water is heated by process and may at times reach temperatures of as high as 200 deg. F. Being hard and unsuitable for boiler feed it is treated by the Neckar process. The equipment consists of a treatment tank with an open heater and vent condenser, chemical feed and proportioning equipment, recirculation and blow-down system and necessary instruments.

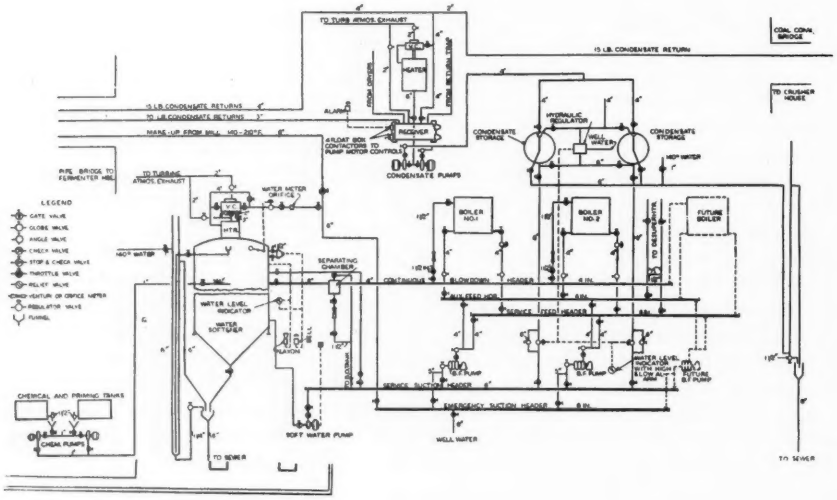


Fig. 11. Water piping diagram in the power plant and feedwater treating equipment in the adjacent dryer building

Water Treatment

Raw water entering the system is measured by a Chronoflo meter. From the meter the water flows through a float operated valve to the vent condenser into an Elliott open heater. The heated water drops from the heater into the central section or reaction chamber of the treatment tank. Boiler water is recirculated and the heat contained in the recirculated boiler water causes a boiling condition in the upper part of the reaction chamber. This boiling removes the air from the raw water and also reduces a large amount of the bicarbonates of lime and magnesium to normal carbones, in this manner initiating the softening process. A mixture of caustic soda and soda ash is introduced near the recirculation inlet and thoroughly mixed with the raw water. Reactions are practically completed in the reaction chamber and precipitates are removed by settling when the water travels upward in the outer space of the tank toward the take-off.

The meter orifice in the raw water line, and the electric flow meter equipment, operated from this orifice, form the basic operating elements of the system. The chemical feed is controlled by an integrator operated from the electric flow meter. This instrument is located between the chemical tanks and contains a cable drum for operation of the decantation pipes. Chemical tanks and pumps are provided in duplicate so that a unit can be made ready for operation before the cycle on the other one has been completed, insuring continuity of the chemical feed.

Complete and instantaneous information on all phases of the water treating system is available to the operator through an instrument panel on the main operating floor. This panel contains the raw water flow recorder and flow recorders, with integrators, for the blow-down from each boiler and for the unused proportion which goes to the sewer. Since the proportion of make-up to total feed varies considerably during the course of twenty-four hours, it is not possible to regulate the recirculation and blow-down in proportion to the boiler feed so only the flow of raw water to the system can be used as a guide.

The treatment tank is located in the building adjoining the power house and a water level indicator is provided on the panel, and high and low water alarms are additional aids for the operators. The panel further contains a recording thermometer, showing the temperature of the effluent of the treatment tank, and pressure gages to indicate the pressure of the steam in the treatment tank and the flash pressure in the recirculation header.

Normally the boiler feed pumps take their suction

Principal Equipment at the Power Plant of Hiram Walker & Sons.

GENERAL

Company.....Hiram Walker & Sons, Inc.
Location .....Peoria, Ill.
Service.....Steam and Power for Distillery
Architects and Engineers.....
.....Smith, Hinchman & Grylls, Inc., Detroit, Mich.

BOILERS AND AUXILIARIES

Boilers—Babcock & Wilcox Co., two, Class XXIV, No. 34, Stirlings with fusion welded drums and baffled for 3 passes. Each boiler has 13,790 sq. ft. of heating surface, made up of 499, 3¼-in. tubes; 2246 sq. ft. of water cooled furnace surface and a 7430 cu. ft. furnace.

Superheaters—Babcock & Wilcox Co., two, convection type, 1331 sq. ft. designed for 110 deg. F. superheat at 150,000 lb. per hr.

Pulverizers—Kennedy-Van Saun Mfg. & Engrg. Corp., one, 10 t. air swept ball mill, driven through worm gears by a 200-hp. Westinghouse type CS 440-v., 435 r.p.m. induction motor. Feeder driven by Westinghouse ½-hp., 440 v., 1150 r.p.m. variable speed motor.

Exhauster—B. F. Sturtevant Co., one, steel plate type, size 71, driven by Westinghouse 40-hp. 440 v., 1100 r.p.m. variable speed induction motor.

Pulverizer—Babcock & Wilcox Co., one, 10 t. type B No. 238 mill, driven by a General Electric 150-hp. 440 v., 720 r.p.m. motor. Feeder driven by a General Electric 440 v., 1740 r.p.m. motor.

Exhauster—B. F. Sturtevant Co., one, steel plate type, size 45-43, on pressure side of mill. Driven by a General Electric 50-hp., 440 v., 1750 r.p.m. motor.

Pulverizer—Babcock & Wilcox Co., one, 3 t. type B No. 132 mill, driven by a General Electric 60 hp., 440 v., 1745 r.p.m. motor. Feeder driven by a General Electric ¾ hp., 1725 r.p.m., 440 v. motor through a Universal gear. This unit is equipped with Aerofin steam heating coils at the entrance to the mill.

Exhauster—B. F. Sturtevant Co., one, steel plate type, size 40-34, on pressure side of mill, driven by a General Electric 25 hp., 440 v., 1160 r.p.m. motor.

Forced Draft Fans—B. F. Sturtevant Co., two, Turbovane size 90, capacity 175,000 lb. air per hr. at 8 in., 100 deg. F. Each fan driven by a Westinghouse type CW, 25 hp., 440 v., 1175 r.p.m. induction motor.

Induced Draft Fans—B. F. Sturtevant Co., two, Turbovane double inlet, size 1006, capacity 230,000 lb. of gas per hr. at 6½ in., 440 deg. F. Each fan driven by a Westinghouse type CW, 250 hp., 440 v., 884 r.p.m. slip ring induction motor.

Air Heaters—Air Preheater Corp., two, Ljungstrom, 14,500 sq. ft., with rotors driven by a Westinghouse type CS, 2 hp., 440 v., 1750 r.p.m. motor through a W. A. Jones Mfg. Co. 1800/20 r.p.m. gear.

Coal Handling Equipment—Robins Conveying Belt Co. Capacity of 75 t. per hr. Equipment consists of: Reciprocating feeder driven at 18 r.p.m. by a 5 hp., 1160 r.p.m. motor through a speed reducer; 30 in. belt driven at 58 r.p.m. through a speed reducer by a 3 hp., 1160 r.p.m. motor delivering coal to a 24 in. diam. by 30 in. long double roll crusher driven through V-belt drive by a 20 hp., 870 r.p.m. motor; from the crusher the coal is carried to the coal bunker by a 24 in. belt driven at 36 r.p.m. by a 15 hp., 440 v., 1160 r.p.m. motor through a gear; and a tripper. Coal from the bunker is delivered to the scales by 3 t. traveling hopper driven by a 2 hp., 1200 r.p.m. motor. All of the above are Westinghouse 440 v. motors with Westinghouse starters, and W. A. Jones Mfg. Co. gears.

Conveyor Belts—United States Rubber Co.

Magnetic Pulley—Dings Magnetic Separator Co. Supplied with direct current from a General Electric 10 amp., 125 v., 1750 r.p.m. motor generator set.

Burners—Babcock & Wilcox Co., six, 4 combination gas and coal; 2 pulverized coal.

Gas Reducing Station — Chaplin-Fulton Mfg. Co. reducing valve with Nordstrom plug valves.

Pilot Light—Babcock & Wilcox Co., using Bailey orifice General Electric diaphragm switch and Ruggles-Klingemann electrically operated valves.

Combustion Control—Bailey Meter Co., with one master panel and two individual boiler panels. Boiler panels consist of indicating steam pressure gage; indicating boiler water level gage; five-pointer draft gage; 3-pen meter recording water flow, feedwater temperature and water level; boiler meter; four-pen recording thermometer giving air and gas temperatures entering and leaving air heater; necessary switches, indicators and control for shifting from automatic to manual control. With the exception of the Ashcroft pressure gages all instruments on the panels are Bailey.

Recording Thermometer — Bailey Meter Co., one, 2-pen recording primary air temperature.

Ash Hoppers—Allen-Sherman-Hoff Co.

Soot Collecting System—Allen-Sherman-Hoff Co.

Blow-Off Valves—Yarnall-Waring Co.

Breeching—Mississippi Valley Steel Co.

Breeching Doors — Feltham Multiplex Door Co.

Coal Scales—Richardson Scale Co.

CO_2 Recorder—The Hays Corp.

Feedwater Regulators—Swartwout Co.

Excess Pressure Regulators—Swartwout Co.

Furnace Walls—Bigelow-Liptak Co.

Plastic Insulation—Wyo-lite Insulating Products.

Furnace Setting—George Allen & Sons.

Gage Columns — Reliance Gauge Column Co.

Safety Valves—Crane Co.

Soot Blowers—Diamond Power Specialty Corp.

Stop and Check Valves—Edward Valve & Mfg. Co., Inc.

FEEDWATER SYSTEM

Boiler Feed Pumps—De Laval Steam Turbine Co., two centrifugals, with capacity of 600 g.p.m. each against a head of 860 ft. Driven at 3,000 r.p.m. by 170 hp. steam turbines operating at full boiler pressure and temperature, and exhausting at 15 lb. gage.

Deaerating Water Heater—Cochrane Corporation. Type 6048-C, with vent condenser.

Receiver Pumps—De Laval Steam Turbine Co., two centrifugals with capacity of 250 g.p.m. each against a head of 100 ft. Driven at 1780 r.p.m. by Westinghouse 10 hp., 440 v. motors.

Receiver Control — Ruggles-Klingemann Mfg. Co., four, float switches.

Condensate Regulator — Swartwout Co., two, controlling flow on feedwater from condensate tank to feedwater heater.

Water Softener Equipment—The Neckar Company, Inc. Recirculating system using caustic soda and soda ash, with capacity of 150,000 lb. per hr. Chemical feed proportioned to raw water feed as metered by a Builders Iron Fnd. Chronoflo meter. Operating panel consists of 8 gages: 2 Ashcroft indicating steam gages; Brown recording thermometer, Brown indicating water level gage; 3 Brown flow meters indicating the blow-down from each boiler and the flow to the sewer. Incoming water heated by an Elliott deaerating heater with vent condenser.

TURBINES AND ELECTRICAL EQUIPMENT

Turbo-Generators — General Electric Co., two, 1500 kw., 3600 r.p.m. Form P turbines, driving 1875 kv-a., 80% power factor, 3 ph., 60 cycle, 480 v. generators and 125 v., 120 amp. shunt wound direct current exciters; throttle pressure, 230 lb., 100 deg. superheat; automatic extraction at 75 lb. exhaust, 15 lb. gage.

Main Switchboard — Westinghouse Electric & Mfg. Co., 1½ in. black ebonite panels.

Control Switchboard—Westinghouse Electric & Mfg. Co. Stretcher leveled steel panels.

Air Circuit Breakers—Westinghouse Electric & Mfg. Co., 21, Type CL, 600 v. solenoid operated.

Generator Switches—Westinghouse Electric & Mfg. Co., two, Type B-6, 3000 amp., 2500 v., 3 pole S.T. solenoid Rectox oil circuit breakers.

Line Switch — Westinghouse Electric & Mfg. Co. Type F-24-A, 1200 amp., 7500 v., 3 ph. S.T. solenoid Rectox oil circuit breaker.

Line Switch Protection — Westinghouse Electric & Mfg. Co., one, SC Transformer overload relay; two, CO overload relays.

Generator Protection — Westinghouse Electric & Mfg. Co., six, CR reverse current relays.

Wiring—Westinghouse Electric & Mfg. Co., switchboard control wiring—Rockbestos high temperature wire. All other not underground, 30% rubber and braid, single conductor, Fire Stop.

Underground Feeder Cables—Habershaw Wire & Cable Co. 3-conductor V. C. lead covered for 1000 v. underground service.

Lead Cable Terminals—Anaconda Wire & Cable Co., air and vacuum type end bells with vacuum, wiped joint.

Distribution Panels—Frank Adams Electrical and Bulldog Electric Products Co., dead front safety type for power and light.

Storage Battery — Philadelphia Storage Battery Co.

Electrical Contractors—Dearborn Electric Construction Co.

MISCELLANEOUS EQUIPMENT

Deep Well Pumps—A. D. Cook Co., Inc., 3, size 16, capacity 2,000 g.p.m. each. Driven by 150 hp., 440 v., 1800 r.p.m. U. S. Electric Mfg. Co. motors with Cutler-Hammer start ers.

Fire Pump—Dayton-Dowd Co., 1500 g.p.m., 110 lb. pressure, driven by General Electric 150 hp., 1750 r.p.m., 440 v. motor with Cutler-Hammer motor control. This pump is bypassed so that well water may be used on the fire system.

Building Contractor—Bryant-Detwiler Co.

Condensate Tanks—Chicago Bridge & Iron Co.

Crane—Whiting Corporation. 20 t.

Desuperheaters—Swartwout Co.

Elevator—Otis Elevator Co.

Exhaust Heads—Swartwout Co.

Piping Contractor—American Power Piping Co.

Valves, Pipe and Fittings—Crane Co.

Reducing Valves—Swartwout Co.

Pipe Covering—Johns-Manville Corp.

Safety Switches—Cutler-Hammer Co.

Steel Contractor—Mississippi Valley Steel Co.

Traps—Crane Company.

from the service suction, supplied usually from the top of the treater tank or in emergencies by the soft water pump from the bottom of the tank. The emergency suction header is supplied by return mill water which bypasses the treater equipment, or, if no overflow is available, from the cold well water system direct. Feeder pumps discharge to the service feed header through S-C regulators to the boiler, or on an emergency, through the auxiliary feed heater to the other end of the back drum by hand control.

It will be seen from Fig. 11 that both the condensate storage tanks and the water treater tank feed the service suction header by gravity, forming a U tube arrangement with the condensate storage tanks on the long leg. In order to proportion the flow from the two supplies, Swartwout regulators have been installed in the two lines from the condensate tanks. These regulators are actuated by the level in the overhead tanks. When the condensate tanks are full the valves are open and the feed pumps take all condensate, back

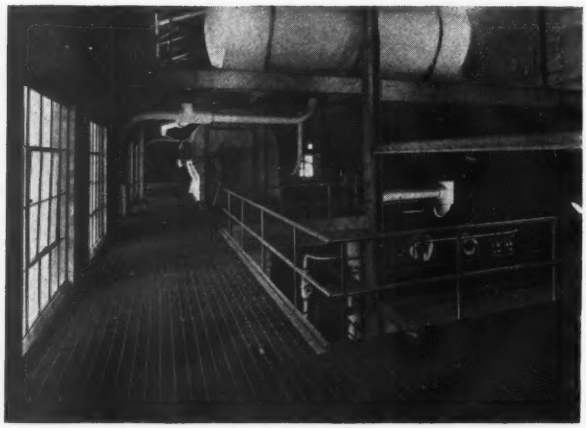


Fig. 12. The top floors with the induced draft fans and condensate storage tanks

flow to the treater being prevented by check valves. As the level in the condensate tanks drops, the valve is throttled and the pumps begin taking some treated water. After the condensate tank level has dropped about four feet the regulating valves are closed and the pumps use all treated water.

With the exception of the sprinkler and fire systems connected to the city water service, all water for the distillery is supplied from three deep wells pumped by three 2000 g.p.m. Cooke deep-well pumps driven by 150 hp. U. S. vertical motors with Cutler-Hammer starters. This water, with a constant temperature of about 53 deg. F. throughout the year, is very hard, running from 500 to 650 p.p.m. Wells are 2 ft. in dia. from 53 to 55 ft. deep and the water comes within about 25 ft. of the surface. One well pumped at the rate of 3600 g.p.m. on test showed a drawdown of 5 ft. The drawdown at 2000 g.p.m. is about 2.5 ft. Water for the mill is treated by a Permutit sulphuric acid treatment to convert the temporary to permanent hardness and prevent scale in the cooling coils.

As water in the process is used at various temperatures up to 180 deg. F. and heat conservation has been carefully considered, a number of storage tanks, as indicated on Fig. 4, have been provided in the mill building to store water at 90, 140 and 180 deg. F. Cold water used in the fermenters goes to the 90 deg. F. tank to be used in the barometric condensers on the cookers. Discharge from these condensers goes to the sewers. The discharge from the still condenser goes to a 140 deg. F. storage tank which overflows to a 180 deg. F. tank on the floor below, through a Griscom-Russell heat exchanger taking the atmosphere flash from the cookers. Water from the mash and slop coolers also goes to the 140 deg. F. tanks. The overflow from the 180 deg. F. tank in turn goes to the power plant to be used for boiler feed make-up. Water at 180 deg. F. from the storage tank, after passing through a Griscom-Russell bent tube heater, using steam at 15 lb. pressure, is used for the cookers, yeast tubs, wort tubs, and Porteus mixers. The water tanks and necessary circulating pumps, Ingersoll-Rand 500 g.p.m. centrifugals, are all located on the lower floor of the mill building. Two Pennsylvania, 80 lb. compressors and two Westco hot water circulating pumps for the hot water service system throughout the plant are also located on this floor.

Steam for building heating is supplied at 15 lb. by a piping system, originating at the still house and making a loop through the high wines building and rack warehouses to the shipping and bottling building with an underground branch to the administration building, as shown by Fig. 3. In general, the heating is by unit heaters although the still building is heated entirely by direct radiation to avoid explosion hazards. The rack warehouses which because of their construction and contents arrangement form an unusual problem, are held at 90 deg. F. by means of a single fan and set of blast coils.

Air conditioning by means of Carrier units with cold water precoolers is provided in the Administration building and in parts of the Bottling building devoted to the bottling equipment and the employees' dining rooms.

Buildings are all built of Illinois common brick, the rack warehouses of solid masonry, bottling and administration buildings of reinforced concrete and the remaining buildings of steel frame construction. The roofs are of hollow rib steel deck construction with 1½ in. of pulp fiber insulation and Johns-Manville asbestos shingles. This provides a quickly constructed utilitarian roof construction, cheap for the service expected and with the further advantage that shelter was provided as soon as the steel deck was laid, a matter of some importance with the construction schedule maintained during the winter months. Although each building was designed specifically to meet its own particular needs in the production process with no frills, there is an architectural achievement acquired largely by accentuating the vertical lines.

(Part II giving further details of the distilling process with steam and water requirements will appear next month.)

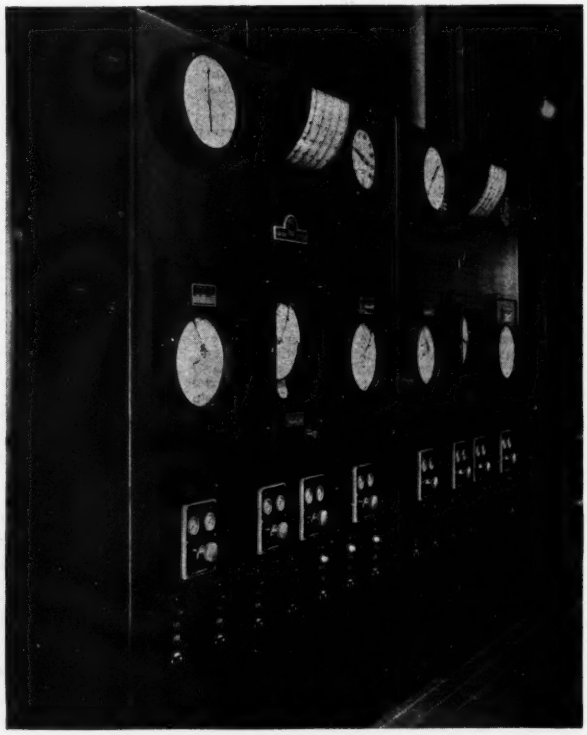


Fig. 13. Boiler Control Panels

Feedwater Treatment for Small Boilers

Thorough Cleaning with Acid and Proper Water Treatment Eliminates Scale and Corrosion. By C. H. Fellows[1]

FOR TWENTY YEARS or more the water used in the locomotive and locomotive cranes which are used for handling coal at the power plants of a large electricity supply company had been treated to prevent the formation of hard scale. Almost every kind of water treating compound that had been offered for the purpose was tried. About 5 yr. ago it was evident that in spite of the fact that the same type of water was used at the Company's six coal handling locations a different kind of feedwater treating reagent was apparently required to keep the boilers reasonably clean. Among the several water treatment formulas that had been tried there were one or two that seemed to be fairly effective; but because the experience among the operators was not uniform it was desirable to attempt to obtain a single treatment that would be satisfactory to all operators and permit the use of a single type of treating reagent.

Examination of several crane boilers revealed a bad scale condition. Calcium sulfate-carbonate scale varying in thickness depending upon the location was found covering the entire inner boiler surface. Before a treatment designed for the prevention of scale could be used successfully this old scale had to be removed and it was desirable to keep the equipment in operation if possible while this was being done. Phosphate salts were first tried but the conditions under which the boilers of this type of equipment operated made it impossible to keep a sufficiently high concentration of alkali or phosphate ions to produce any appreciable effect on this old scale without creating a serious carry-over condition. After several trials in which carbonate as well as phosphate was used, it became evident that it was impracticable to attempt to remove this scale without taking the equipment out of service. This was done.

Cleaning with Acid

With the equipment out of service the obviously best way to remove the scale was by the use of an acid to dissolve it. There have been recorded several instances where acid had been used to clean steam lines and boilers of scale and rust so the procedure was not novel. Its application to this type of equipment and the details of procedure may, however, be of interest and of value to many operators who may be confronted with the same problem.

Before the acid treatment was actually applied to the boilers several control tests were carried out in the laboratory to establish the most desirable concentrations to use and to demonstrate to the operators that acid could be used without harming the boilers. In order to inhibit the action of the acid on the base metal an inhibiting material such as "Incontrol" or "Rodine" was used with the acid. The preliminary tests indicated that with these inhibitors the loss of iron in a twenty-four hr. immersion period with a hot 10% acid solution was less than 0.01 per cent. All hard scale was removed from a specimen of scaled boiler tube within 1 hr. without stirring or otherwise agitating the solution.

Muriatic acid (a commercial grade of hydrochloric acid) was used in applying this cleaning process to the boilers. A water solution containing 10 per cent of acid by weight to which was added an amount of inhibitor equal to one per cent by weight of the acid was used as the cleaning solution. This solution was made up inside the boiler by adding water and introducing the acid in small quantities to preclude the possibility of creating local high acid concentrations.[2] The inhibitor was introduced with the water. A wood-fire was built under the boiler after completion of the filling process in order to raise the temperature of the cleaning solution and to promote circulation within the boiler. The temperature of the solution was maintained at about 160 deg. F. for a period of 4 hr., the boiler being vented to the atmosphere during this time.

Soda Ash Neutralizes Acid

At the end of this heating period the acid solution was drained from the boiler and discarded. The boiler was then thoroughly washed with water. This operation flushed out a considerable quantity of loosened but undissolved scale which in the case of the first two boilers to be cleaned was weighed before discarding. Ten pounds of soda ash were then introduced into the boiler with sufficient water to fill it to insure the complete neutralization of any free acid remaining. This solution was boiled for half an hour and drained to the sewer.

An inspection of the boiler indicated that practically all of the scale had been removed. As far as could be seen no scale remained on the tubes, and only a small amount around the edges of the crown-sheet. The metal was free of rust and there were no indications of damaging solution of the iron. A certain amount of iron was found in the acid solution upon analysis; but this was attributed to rust that had been dissolved. The analysis of this acid solution showed an amount of calcium equivalent to about 150 lb. of calcium sulfate. An equal amount of dry undissolved scale was washed out of the boiler during the flushing operation.

Subsequent Water Treatment

The feedwater used in this equipment is untreated Great Lakes water. This water is characterized as a bicarbonate water containing calcium and magnesium salts in concentrations of about 27 and 5 p.p.m., respectively. It has an alkalinity of about 85 expressed as p.p.m. $CaCO_3$ of which about 80 p.p.m. is bicarbonate alkalinity. The use of alkaline phosphate salts introduced with feedwater of this nature will lead to feed line deposits and for that reason is objectionable for this equipment. Soda-ash may, however, be

[1]Chemist, Research Department, The Detroit Edison Co., Detroit, Mich.

[2]In making the dilute solution it should not be forgotten that handling the concentrated acid involves a hazard to clothes and body. Care should be exercised to prevent splashing and particularly to protect the eyes. The use of the inhibitor for all practical purposes stops all reaction on the base metal so that even prolonged treatment is not likely to do damage.

used without the formation of such deposits. Experiments indicated that a solution of 50 gal. of water to which 50 lb. of soda-ash and 2.5 lb. of tannic acid had been added would effectively prevent the development of scale and corrosion when used in proportions of 1 qt. to each 1000 gal. of water.

The nature of the operation of this type of equipment makes this treatment simple to apply by the locomotive or locomotive crane operators. Subsequent examinations of these boilers have indicated no signs of hard scale and no serious corrosion over a period of four years.

Fly Ash *for Cleaning* Turbine Blades

After trying various methods and experimenting with different materials, fly ash was found to give most effective results at Cahokia Station.

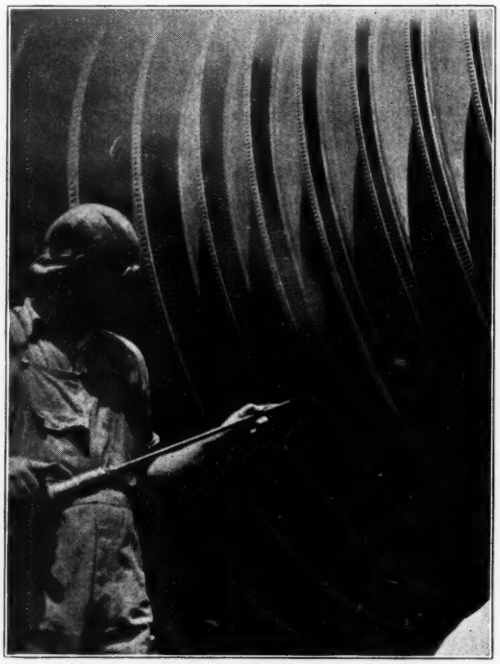
By Edward Luxemberg

ONE of the major problems confronting the maintenance crews from year to year in steam power plants such as Cahokia is the cleaning and preservation of the steam turbine generators. Turbines that have been in almost continuous service for a year or more and have been carrying from a tenth to as much as a fourth of the system load require a thorough inspection and overhauling.

The most difficult task in the cleaning process is the removing of a very thin layer of scale and "dust" particles from the turbine blading. No steam is entirely free from suspended matter and as each hour tons of steam pass over the turbine blading at high velocities some of the foreign matter adheres to the blading which thus becomes gradually encrusted with a thin coat of very hard scale. This reduces the efficiency of the unit.

Several methods have been employed to remove this blade scale—the more obvious one being the use of steel scrapers. Because of the variety of blade shapes, however, many special scrapers are needed. Furthermore, since such work must be done by hand it is slow and tedious. Another method of cleaning blades is that of sand blasting. Sand is highly abrasive, and readily removes the hard material but at the same time, because of the hard sharpness of the particles, sand blasting is destructive to the blade metal. Certain acids have been tried, but their chemical action on the metal is deleterious. Pulverized coal will clean successfully when blown by compressed air through a regular gunite machine, but this material is not quite hard enough for rapid progress.

The ideal cleaning method would seem to be one utilizing the sand blast principle but using a material that will blast away the scale quickly and at the same time not injure the blade. In a search for some such material it appeared that fly ash, which results from the combustion of pulverized coal and settles at the base of smoke stacks, had about the proper characteristics of fineness, cheapness, and abrasiveness. Fly ash is exceedingly fine and handles readily in the blower. Practically all of it will pass through a sieve having 200 wire strands to each linear inch or 40,000 openings to the square inch. The particles, while reasonably hard, are not as sharp as sand, being well rounded in the burning process. As a by-product of the boiler room unlimited quantities are available at practically no cost.



Cleaning Turbine Blades with Fly Ash

Accordingly fly ash was tried in a gunite blower using compressed air to clean the turbine rotor of a 50,000 kilowatt turbine. Results were very satisfactory, only two men being required to do the entire job and in about half the time formerly required for scraping. To verify the expectation that the ash was not wearing away the metal a spare blade was weighed on a laboratory balance before and after cleaning. Calculations showed that less than 0.0005 of an inch of metal was worn away.

The trial demonstrated that blasting with fly ash is superior to any other method for cleaning turbine blades previously employed. It is economical in labor; as a waste material from the pulverized fuel boilers at the plant the fly ash is inexpensive; and what is most important of all, the turbine blades are not damaged.—Union Electric Magazine.

TESTS OF a new liner for combustion engine cylinders, made by Barimar Ltd. of London, Eng., and consisting of an alloy of iron with chromium, have shown wear of only 1/1000 in. in cylinder diameter for 5240 mi. of automobile travel; also in a marine engine of $9\frac{13}{16}$ in. diam. by 13 in. stroke, apparently no wear after 650 hr. use over a 6-mo. period, as indicated by no increase in fuel and lubricating oil consumption over that of the new engine.

Improving the Industrial Steam *and* Power Supply

Back Pressure and Extraction Equipment Pays Good Dividends. In Plant Analyzed New Plant Saves Over $200,000 Per Year and Extraction Feed Heating Another $40,000

By
Walter P. Gavit *

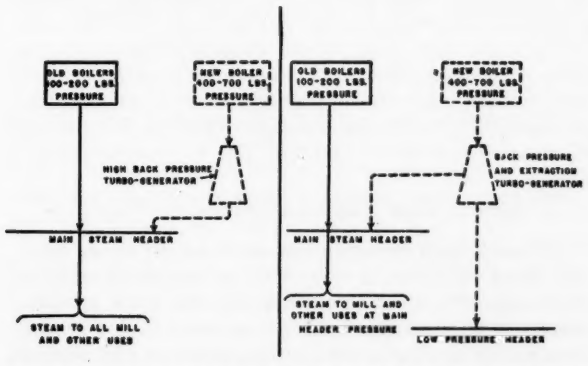
STEAM AND POWER COSTS are a large item in most industries and savings in this department can readily be sufficient to turn a deficit into a profit. For instance, in a sulphate or soda mill the total direct cost of steam and power often runs in excess of $10 per ton of pulp. By taking advantage of methods and systems now available this cost may be reduced to something like $5 per ton of pulp. The majority of mills operate on steam pressures of less than 200 lb. per sq. in. In such cases an opportunity is offered for large savings in the cost of power and steam by superimposing upon the existing system a high pressure boiler with either a high back pressure or extraction type turbine. In selecting an arrangement for a given mill, local conditions will dictate the type of cycle that should be used. Existing turbines or other equipment in good condition should be retained and used as part of the cycle unless it can definitely be shown that a profit will accrue from replacement with new equipment.

The cycle involving superimposition of a high pressure unit on an existing system is shown in its simplest form in Fig. 1. In this case no change in existing equipment or piping is made. High pressure boilers with a turbine arranged to exhaust at the same pressure as that in the existing steam header system are installed and the turbine exhaust connected to the existing header. Steam passing through the high pressure turbine generates power with a fuel consumption about one-fifth of that ordinarily required to generate with a 150-lb. saturated steam in a condensing turbine. The power generated in a high pressure turbine replaces an equal amount previously generated from steam at plant header pressure or replaces purchased power.

Few actual paper mill systems can be reduced to as simple terms as this. Practically all of them use steam at an intermediate pressure of around 30 lb. per sq. in. It may frequently be advisable, therefore, to install a cycle such as is shown in Fig. 2. In this case the turbine is designed to exhaust at the lower pressure and is provided with a bleeder or extraction opening from which steam is supplied to the plant header. The valve and governor arrangements on these turbines are designed so as to maintain constant pressure at the exhaust and extraction openings with demands for steam at the two pressures varying independently.

A third arrangement is shown in Fig. 3. In this instance a condensing turbine is used which is provided with two bleeder or extraction openings, one to supply steam at the mill header pressure and the other at the lower pressure of 25 or 30 lb. This arrangement has certain disadvantages that should be considered before it is adopted. The governor and bleeder pressure control system is more complicated than in either of the two arrangements previously described. The necessity for controlling the pressure at both bleeder openings and passing excess steam on to the condenser requires throttling or by-passing of steam for all conditions of electrical and steam demand except the one combination for which the unit is designed. Throttling or by-passing decreases the efficiency of the turbine to an extent depending upon how far the conditions of the actual operation depart from the ideal design condition. It is of course impossible to predetermine exactly what the operating conditions will be and in actual operation the steam loads at the two pressures and the electrical load vary quite independently. Because of these factors it is almost certain that there will be but little time when the unit will be operating under conditions approximating the ideal for which the unit is designed. A number of turbines of this type have been installed and are in successful operation and where conditions do not permit a satisfactory arrangement with the back pressure and single extraction unit they should be used in preference to sacrificing economy through an unbalanced arrangement. Where there are condensing turbines in the old plant the back pressure and extraction type of unit will usually be found to be the more economical.

*United Engineers and Constructors, Inc., Philadelphia, Pa.
From a paper presented before the T.A.P.P.I.


OLD BOILERS 100-200 LBS. PRESSURE
NEW BOILER 400-700 LBS. PRESSURE
HIGH BACK PRESSURE TURBO-GENERATOR
MAIN STEAM HEADER
STEAM TO ALL MILL AND OTHER USES
OLD BOILERS 100-200 LBS. PRESSURE
NEW BOILER 400-700 LBS. PRESSURE
BACK PRESSURE AND EXTRACTION TURBO-GENERATOR
MAIN STEAM HEADER
STEAM TO MILL AND OTHER USES AT MAIN HEADER PRESSURE
LOW PRESSURE HEADER

Figs. 1 and 2. Two simple cycles utilizing high pressure equipment

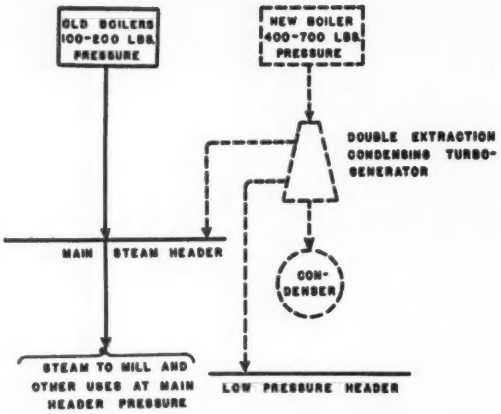

OLD BOILERS 100-200 LBS. PRESSURE
NEW BOILER 400-700 LBS. PRESSURE
DOUBLE EXTRACTION CONDENSING TURBO-GENERATOR
MAIN STEAM HEADER
CON-DENSER
STEAM TO MILL AND OTHER USES AT MAIN HEADER PRESSURE
LOW PRESSURE HEADER

Fig. 3. Double extraction units can sometimes be used

The foregoing remarks as to the Fig. 3 arrangement apply also to that in Fig. 2 but to a much lesser extent. The high back pressure single extraction turbine has been developed to a point such that in present day machines regulation of back pressure and bleeder pressure is steady and operation is continuous and reliable. Figures 4 and 5 and Table I are given to show the effects of installing high pressure cycles of the general type that have been discussed. Figure 4 shows first an assumed existing paper mill steam and power system greatly simplified for the sake of clarity.

To this is added, in dotted lines, a high pressure boiler and a high back pressure extraction type turbine. The arabic or vertical figures on the diagram show the assumed steam flow and power generated for the typical paper mill without the high pressure system. The italic or slanting figures show the steam flow and power generation after the high pressure system is installed. Demands for steam and electrical energy have been assumed which are representative of a medium sized paper mill probably about 250 t. of pulp per day.

In the case chosen, it is assumed that all electric power is generated on the premises and that part of the manufacturing equipment is driven by steam. The figures shown represent a steam consumption of about 32,000 lb. per t. of pulp. This figure varies in different mills depending upon the type of product, type of equipment, whether electric power is purchased and other factors peculiar to a given mill but it is believed that the values used are sufficiently representative to

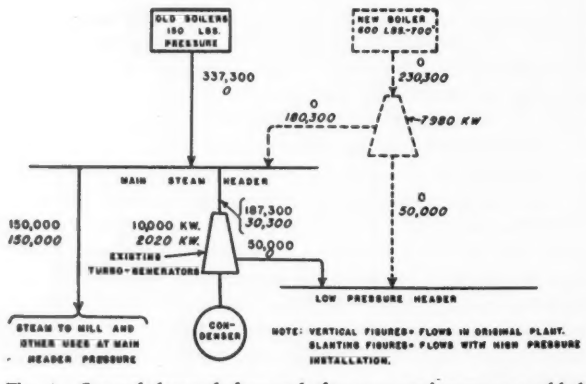


Fig. 4. Steam balances before and after new equipment was added

serve as an illustration of what may be expected from an installation of the kind under discussion.

In order to keep the illustration as simple as possible no account is taken of steam that might be available from waste material such as wood room bark or recovery plant waste heat boilers. It will be noted that with the high pressure cycle added the old boilers produce no steam and that most of the power formerly generated by the condensing units is produced in the high pressure turbine. Table I shows the principal data referring to this diagram and Fig. 5.

In the foregoing figures, feedwater heating has been omitted entirely for the sake of simplicity. The tendency in modern power plant practice is to heat feedwater with steam extracted from the turbines. The value of this practice has been so conclusively proven as to permit no argument. Figure 5 is given to show the effect of applying this principle in the paper mill power plant. The fundamental data is the same as in Fig. 4. By comparing column C with column B in Table I, the effect is clearly shown. It will be noted that the total steam produced is increased from 230,300 lb. per hr. to 268,100, but on account of the increase in feedwater temperature, the total

Table I. Tabulated data referring to Figs. 4 and 5

	A	B	C
	Assumed for existing plant	With high press. Boiler and Turbine as described	Same as B but with feed heating
150 lb. Steam—Mill uses lbs. per hour..	150,000	150,000	150,000
30 lb. Steam—Mill uses lbs. per hour..	60,000	50,000	50,000
150 lbs. Steam Condensing Turbines....	187,300	30,300	0
Total 150 lbs. Steam.....	337,300	180,300 [1]	150,000 [1]
Total 600 lbs. Steam.....	0	230,300	268,100
Feed Water Temperature, Deg. F.....	70°	70°	361°
Assumed Boiler Efficiency, per cent....	70	80	80
Total heat required in fuel.....	559 x 10^6	378 x 10^6	341 x 10^6
Kw. generated in back press. turb.....	0	7,080	10,000
Kw. generated in 150 lbs. cond. turbs...	10,000	2 920	0
Cost of fuel per ton (13,000 B.t.u. per lb.)	$4.00	$4.00 [2]	$4.00 [2]
Total cost of fuel per year of 7200 hours	$619,000	$418,000	$378,000
Saving due to high pressure installation alone	.....	$201,000	.....
Additional saving due to feed heating with extracted steam	.....	.....	40,000

heat requirement in fuel is reduced from 378 $\times$ 10^6 B.t.u. to 341 $\times$ 10^6. The power generated in the high pressure turbine is increased from 7,080 kw. to 10,000 kw.

The tabulation shows a gain of $40,000 per year due to feedwater heating. This is, of course, not all due to the use of extracted steam for feedwater heating, as some of it could be realized by using exhaust from steam driven auxiliaries. In the usual circumstances it is more economical to use motor driven auxiliary equipment in the power house and heat the boiler feedwater with steam extracted from the turbines. The convenience of motor driven auxiliaries is self evident and the extraction heater arrangement automatically maintains a balance between the amount of steam required for heating and the amount available.

Adding High Pressure System to Plant

When a high pressure system is added to an existing plant to secure a reduction in operating cost, no spare capacity need be included in the high pressure installation. In case the high pressure boiler or turbine has to be shut down for maintenance and repairs, the plant simply returns to the old method of opera-

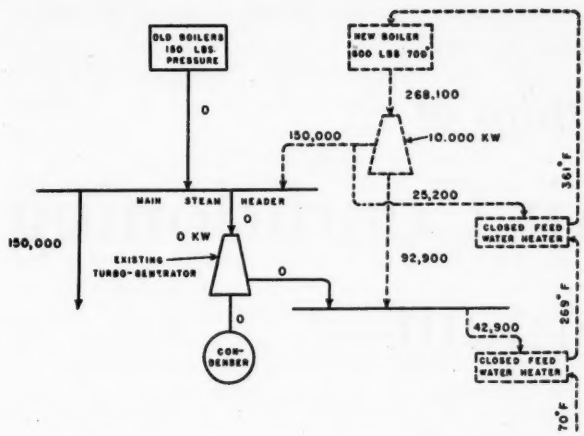


Fig. 5. Extraction feed heating added to Fig. 4

tion until the high pressure equipment can be returned to service. Present day boiler and turbine equipment have a high degree of reliability. With proper feedwater conditions, high pressure boilers can be kept on the line continuously for 6 mo. or more. Steam turbines, when properly operated, can be kept in continuous service for longer periods and, in fact, should not be shut down and started up oftener than is absolutely necessary. Damage to turbines occurs during starting and stopping more often than when running on load.

There is a wide range of cycles and pressures to select from in designing a system for an industrial plant. In a given case the system selected must be adapted to all the special conditions existing therein. It must be one that will fit in with and take the fullest economical advantage of whatever power equipment exists in the plant. It is evident, therefore, that the design of the most suitable system requires a complete knowledge of the possibilities available in present day steam power engineering. It also is important that the designer have a knowledge of the problems of the industry and that he coöperate fully with the engineers of the plant in which he is working. There are many plants today in which improvements have been made that fall far short in earning capacity of what might have been accomplished. Such instances are due to insufficient knowledge on the part of the designers or incomplete analysis of local conditions.

More Gold By Air Conditioning

FOR THE Robinson Deep Mine near Johannesburg, S. Africa, an air-conditioning installation is under way to regulate temperature and humidity so as to allow deeper working and increased production from the rich lower level veins.

At the bottom of the mine, some 8000 ft. below the surface, temperature of 100 deg. F. and high humidity make working difficult, reduce physical activity some 70 per cent and are even often fatal to mine workers. By cooling and dehumidifying the air, these difficulties will be greatly decreased, with a probable measurable addition to the world's gold supply, some half of the world's annual supply coming from the South African mines.

When completed, this will be the largest air-conditioning system on record, supplying 400,000 cu. ft. of air a min. and using 2000 t. refrigeration. Carrene, a safe refrigerant, will be used, in three Carrier centrifugal machines of 750 hp. each, the condenser water required being 7500 g.p.m., recooled in a spray pond the size of a football field.

Dehumidifying and cooling of air will be in a spray chamber near the refrigerating machines, 50 ft. long by 16 ft. high, using 8400 g.p.m. of spray water and removing a maximum of 1500 g.p.m. of water from the air. Blowers carry 23,600 lb. of air per min., more than the weight of ore removed from the mine, from the spray chamber to an underground tunnel which enters the mine shaft some 100 ft. below the surface. Some 3000 hp. will be required to operate refrigerating machines and pumps.

What rate of increase of gold production will be secured is conjectural but, as more than half of the world's annual gold supply comes from the African mines, any considerable percentage of increase from those mines, of which some 40 are in operation, will be a substantial addition to the annual gold output of the world.

Survey of the problems involved in the air-conditioning system was made by D. C. Lindsay, an engineer of the Carrier Corpn., working with Sydney Thompson & Co., mine engineers, of Johannesburg. The system was designed under supervision of Willis H. Carrier, who has been responsible for many large installations in the United States, that at the Rockefeller Center being the most notable.

Lakeside Boiler Availability

FURTHER PROOF of the high availability factors of high-pressure installations is found in the record of Boiler Room No. 3 at Lakeside Station of the Milwaukee Railway & Light Co. This boiler room contains four units operating at 1300-lb. steam pressure and 750 deg. F. steam temperature. The first unit was installed in 1926 and the others in 1929-1930. Disregarding the first unit, which because of the superheat and reheat arrangement is slightly less flexible, the average availability for the three later units for the year 1933 was 98.1 per cent. The number of times these boilers were banked during the year were, respectively, 224, 230 and 233, and of the time the units were actually out of service only about 60 per cent was chargeable to maintenance. These units are of the Combustion Engineering bent-tube type, rated at 250,000 lb. of steam per hr. but operated at times up to as high as 350,000 lb. They are fitted with radiant type superheaters and fired with a bin-and-feeder pulverized coal system in which the mills are located directly in front of the boilers and the coal dried in the mills by waste flue gases.

EXACT MEASUREMENTS made in cases where thinking is immediately translated into action show that in noisy surroundings men work harder, accomplish less and make many more errors.—Industrial Bulletin of Arthur D. Little, Inc.

Data Used in the Application of

Heating *and* Air Conditioning Equipment

WITH THE APPROACH of winter, the need for data on heating and air conditioning equipment becomes urgent. While the fundamentals of heating have not changed radically in recent years, investigations carried on in practical applications and in laboratories through coöperative arrangements with engineering societies, manufacturers and educational institutions have qualified former practice, making possible more economical and more satisfactory systems. In this article an effort has been made to present in handbook form essential engineering data gathered from authoritative sources on heating and air conditioning equipment needed for checking the design of existing systems or in making plans for modernization.

In steam heating systems, the unit, known as a radiator, which transfers the heat either by radiation or conduction or both from the steam to the air, may take a number of forms depending upon the particular service of the unit. Pipe coils are extensively used in factories where large spaces are to be heated. They are usually located along the side walls or ceilings, are inexpensive and easily installed, but the radiating surface is not the most efficient and such units are objectionable where appearance is important.

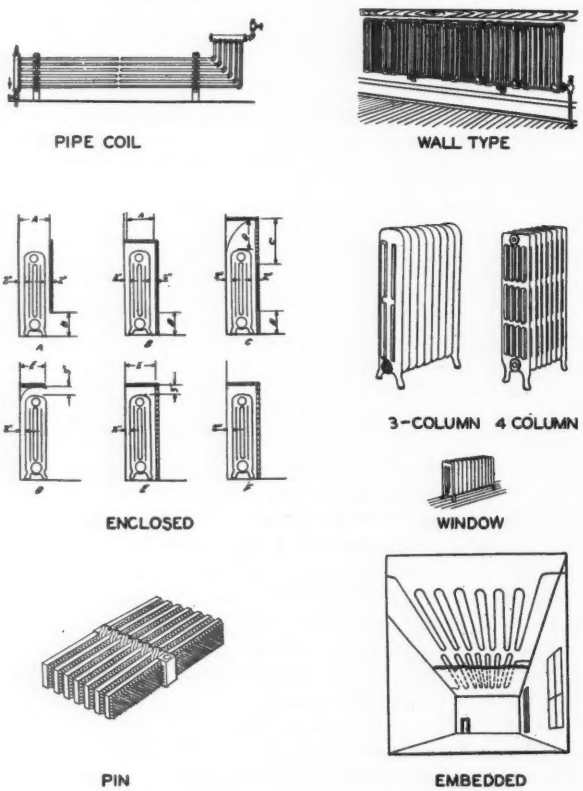


Fig. 1. Types of radiating units used in heating systems. Pipe coils; cast-iron radiators—wall, column, window; Enclosed, various degrees; Indirect, pin type; Panel—embedded

Cast-iron radiators are the most commonly used except where large spaces are to be heated. These may be of either the wall type arranged along the inside surface of an outside wall or ceiling, or the column type placed in the most advantageous position in the room. The surfaces of these radiators are designed for highest heat transfer both by radiation and convection.

Architectural requirements are sometimes such as to demand placing the radiator in a grill encasement, in an open recess in the wall, or in an entirely enclosed recess with grill top and bottom for natural air circulation. Column type radiators serve well for this purpose but radiation is obstructed and greater surface is required. This problem may sometimes be solved by the use of indirect radiators placed entirely outside the room in an enlarged section of duct supplying air to the room. The air may be moved either by gravity or by fan if greater capacity is needed. The type of radiator used here should have the highest radiating efficiency possible as it is completely concealed and has no other function to perform. The pin type radiator is well suited for this purpose.

Panel or plate type radiators are being introduced to permit any type of wall or ceiling decoration. Two methods are employed, one uses pipe coils embedded in the concrete or plaster of the walls, ceiling or floors, the other employs heated plates or panels attached to the interior surfaces of the structure. They permit a wide variety of applications.

Table I. Heat emission of direct pipe coil radiators for steam

Values given in B.t.u. per lineal foot of the coil, not pipe, per hour when the steam temperature is 215 deg. F., room temperature 70 deg. F., coils vertical, pipes horizontal.

Size of Pipe	Rows of Pipe in Coil						
	1	2	4	6	8	10	12
1 in.	132	252	440	567	651	732	812
1¼ in.	155	312	545	702	796	907	1005
1½ in.	185	348	616	793	907	1020	1135

Heat emission values to be used per lineal foot of pipe

Coils vertical, pipes horizontal, 1¼ in. coil 10 ft. high - 100 B.t.u.
Coils horizontal, pipes horizontal, ceiling location 1 -in. coil - 126 "
" " " " " " 1¼-in. " - 146 "
" " " " " " 1½-in. " - 175 "

Heat Emission of Various Types of Radiators

Several factors enter into the problem of estimating the ability of a given radiator to emit heat, as indicated by the accompanying tables. Cast-iron radiators are usually rated in equivalent square feet of surface, each equivalent square foot being considered as capable of emitting 240 B.t.u. per hour with steam at 215 deg. F. and a room temperature of 70 deg. The amount of surface is, of course, the most important factor, but the character of the surface whether rough or smooth, bare or painted, must not be overlooked. The arrangement and location of coils, the form and proportions of radiators and their location in the space to be heated, and the degree of inclosure employed for decorative purposes as well as the air circulating methods employed, all tend to complicate the problem of estimating the amount of heating surface required.

Comfort to the occupants is the object to be obtained in heating rooms. The temperature should be practically uniform through the zone of occupancy which extends over the floor space to a height of around 6 ft. Ceiling radiators, though sometimes necessary, are not very effective as they do not cause a circulation of air and only by radiation can the heat reach the zone of occupancy except by artificial means. The best location for radiators for inducing air circulation and obtaining uniform temperature throughout the room is in the space in front of and below windows or near the floor along outside or the coldest walls of the room, other locations foster uncomfortable drafts and cold spots throughout the room.

Table II. Heat emission of cast-iron radiators for steam

Values given in B.t.u. per hr. per sq. ft. of surface for a temperature difference of 150 deg. F.

Type of Radiator	Height of Radiator, inches			
	22	25	32	38
1 col.	285	279	275	270
2 col.	270	265	257	250
3 col.	255	248	240	231
4 col.	240	235	225	218
Window Radiator			277	
Wall Radiator (horizontal)			293	
Wall Radiator (vertical)			285	

Enclosed - see Fig. 1 for arrangements		Alteration from above values
Arrangement A	with dimensions B = 0.80 A	10% increase
B	" " B = 0.80 A	5% increase
C	" " B = 0.80 A, C = 1.50 A, D = A	No change
D	" " E = 0.50 A	10% reduction
	" " E = A	20% reduction
	" " E = 1.50 A	35% reduction
E	" " E = A	30% reduction
F	as shown	5% reduction

Table III. Comparison of radiator finishes

Finish	Area Sq. Ft.	Coefficient of Heat Trans. B.t.u.	Relative Heating Value Per Cent
One coat dull black Pecora paint	27	1.76	100.0
Bare iron, foundry finish	27	1.77	100.5
Gray paint dipped	27	1.78	101.1
One coat of aluminum bronze	27	1.60	90.8

Heat Requirements

In heating a room, heat must first be supplied to bring the temperature up to the comfort point, from that time on the amount of heat required is that necessary to make up for radiation from the building in addition to that required to heat the fresh air supplied. The heat transmission losses may be calculated from the following formula:

$$H_t = A\,U\,(t - t_o)$$

Table IV. Heat losses from building surfaces

Values given in B.t.u. per sq.ft. per deg. difference per hr.

Type of Wall *	Thickness of Wall, In.									
	4	8	12	16	20	24	28	32	36	40
Brick	0.60	0.42	0.30	0.24	0.21	0.19	0.17	0.15	0.13	0.12
4-in. additional stone face	- -	0.38	0.26	0.22	0.20	0.18	0.16	0.14	0.12	0.11
Concrete or Sand Stone	0.65	0.48	0.41	0.35	0.32	0.29	0.26	0.24	0.22	0.20

*These constants apply to walls plastered on inside; for walls not plastered, add 10 per cent; for walls furred and plastered, decrease by 5 per cent.

Wall surfaces of frame buildings, lathed and plastered on the inside with outside wall as follows:

Ordinary clapboards	- 0.46	Same with 3/4 in. sheathing and paper lining	- 0.35
Same with paper lining	- 0.34	Unlined corrugated iron	- 0.60
Same with 3/4-in. sheathing	- 0.30	Same on t. and g. boards	- 0.40

Glass Surfaces

Single windows	1.0	Double skylight	0.5
Double windows	0.5	Doors considered the same as windows	
Single skylight	1.0		

Roof Surfaces

Concrete, with cinder fill	- 0.50	Slate, with sheathing	- 0.35
Slate, no sheathing	- 0.74	Patent tar and gravel	- 0.86

Partitions

Lath and plaster on studding	0.60
Lath and plaster both sides and studding	0.34

Floors

Single wood flooring, no plaster beneath	0.28
Single wood flooring, plaster beneath	0.20
Double wood flooring, no plaster beneath	0.24
Double wood flooring, plaster beneath	0.18
Concrete on ground	0.40
Wood near ground	0.30
Dirt (no floor)	0.50
Temperature of ground taken at 50 deg.	

Ceilings

Lath and plaster, no floor above	0.40
Lath and plaster, wood floor above	0.36

Where

H_t = B.t.u. per hour transmitted through the material of the wall, glass, roof or floor.

A = area in sq. ft. of wall, glass, roof or floor through which heat may be transmitted and thus lost.

U = coefficient of heat transmission for the material through which heat may be transmitted, in B.t.u. per sq. ft. per deg. difference per hr.

$t - t_o$ = temperature difference between inside and outside air, in which t must always be taken at the proper level, not necessarily the breathing-line. For ordinary purpose, t may be assumed as 70 deg. and t_o as 10 deg. above the lowest recorded temperature for the community.

In using this formula, the values of A and U must be determined or assumed for each surface involved. In general five kinds of surfaces are involved: outside walls; outside glass; inside walls or partitions next to unheated spaces; ceilings of upper floors; and floors of heated rooms above an unheated space. Values given in Table IV are averages given by several good authorities.

To the result secured by working out the radiation losses must be added the heat required to raise the temperature of the fresh air supplied to the room. Under ordinary conditions, rooms under 10,000 cu. ft. contents require one complete change of air per hour which is usually supplied by infiltration. In entrance halls, vestibules and the like, three changes per hour may be used in calculations, the formula being:

$$H_1 = 0.018\ Q\ (t - t_o)$$

Where

H_1 = B.t.u. per hr. required for heating air leaking into building from outside temperature, t_o, to inside temperature t

Table V. Pipe sizes for two-pipe gravity return system

Supply Pipe, In.	Return Pipe, In.	Square Feet of Radiation 2 lb. Pres.	Square Feet of Radiation 5 lb. Pres.
1	1	40	60
1¼	1	80	120
1½	1¼	120	200
2	1½	280	500
2½	2	550	900
3	2½	900	1500
3½	2½	1350	2300
4	3	1950	3300
4½	3	2750	4600
5	3½	3700	6200
6	3½	6000	10000
7	4	9000	15000
8	4	12800	21600
9	4½	17600	30000
10	5	23200	39000
12	6	37000	62000
14	7	54000	92000
16	8	76000	130000

Table VI. Pipe sizes for single pipe gravity return system

Supply Pipe, In.	Square Feet of Radiation 2 lb. Pres.	Square Feet of Radiation 5 lb. Pres.
1	30	50
1¼	70	100
1½	100	150
2	250	300
2½	500	700
3	850	1200
3½	1250	1800

Q = cu. ft. of air entering per hr. measured at inside temperature t

0.018 = the product of the specific heat (0.24) by the density (0.075) of the air, the latter being variable but considered sufficiently accurate for practical purposes.

The sum of all these heat losses given in B.t.u. per hour is the requirement for ordinary exposure and should be increased for rooms with extreme conditions as follows: Rooms with north or west exposures, add 10 per cent; northwest corner rooms, add 15 per cent; buildings heated at long intervals only, add 25 per cent; rooms with high ceilings, add 2 per cent for each foot over 12 ft. This total result divided by 240 gives the equivalent square feet of radiator surface required for the rooms under consideration.

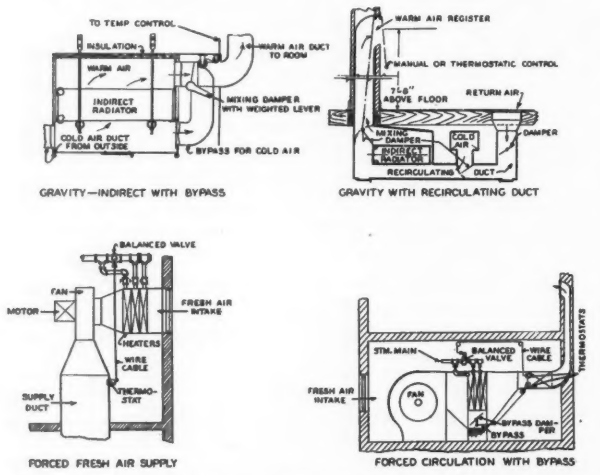


Fig. 2. Common arrangements of equipment in indirect heating systems

Pipe Sizes

Four factors enter into the calculation of the proper size of pipes to use in supplying steam to radiators and returning condensate to the boilers. These are: the initial pressure and the total pressure drop for both the steam and condensate; maximum velocity of steam allowable for quiet and dependable operation of the system; equivalent length of run from the boiler to the farthest heating unit; and the unusual conditions in the building to be heated.

Taking these factors into account, Tables V and VI may be used with satisfactory results in designing or checking heating systems.

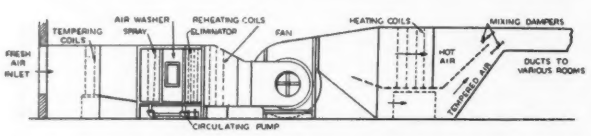


Fig. 3. Common arrangement of air conditioning equipment known as individual direct system

Indirect Systems

In large rooms, particularly those with high ceilings such as auditoriums, theaters and assembling rooms in factory buildings, natural circulation of the air cannot be depended upon to heat the room to a uniformly comfortable temperature. This condition has led to the development of indirect systems of heating in which the heat supplied the room is entirely by conduction, air having been heated by contact with radiators is delivered to the room at the most advantageous points either by natural or forced circulation, common arrangements of equipment being shown in Fig. 2.

Two methods of calculating the proper duct sizes in indirect heating systems have been used with satisfactory results. In the first the desired maximum air velocity is assumed arbitrarily, the velocity being reduced from the fan outlet to the point of discharge into the room. The pressure losses are calculated separately for each section of the duct and the total loss determined by adding the losses in the sections leading to the room outlet. In the second method the duct is designed for equal friction pressure loss per foot of length.

For public buildings, standard air velocities through various openings and ducts are as follows: Outside air intake, 1000 f.p.m.; heater connections, 1000 to 1200 f.p.m.; main discharge duct, 1200 to 1600 f.p.m.; branch ducts, 600 to 1000 f.p.m., and vertical flues, 400 to 600 f.p.m.; registers or grills, 200 to 400 f.p.m., or 250 to 500 f.p.m. if diffusers are used. Department stores may use maximum velocities of 2000 to 2200 f.p.m. in main ducts and industrial buildings, where noise is not an important factor, velocities as high as 2800 to 3000 f.p.m. may be used.

With one heater supplying several rooms or sections of a building, the building is divided into zones and the volume of air necessary to heat the building is proportioned according to requirements as nearly as possible by selecting ducts of proper size, dampers in ducts and registers being employed to reduce the maximum available supply to that specifically desired in individual rooms. The sizes of branch pipes necessary to carry the proper proportion of air are based on the general assumption that the coefficient of friction varies inversely as the 1/7 power of the capacity.

Temperature of the air leaving the register varies in practice from 100 to 120 deg. F. in public buildings, and may reach 140 deg. in factories. The outlet temperature in ventilating or air conditioning systems may be calculated from the following formula:

$$t_y = \frac{52.2H}{Q} + t$$

where t_y = outlet temperature; H = heat loss of room, B.t.u. per hr.; Q = total volume of air to be introduced cu. ft. per hr. measured at temperature of room, t.

The desirable fan capacity can be determined by means of this formula, first by calculating H as has been explained, then assuming values of t_y and t. By transposing we have

$$Q = \frac{t_y - t}{52.2H}$$

As manufacturers rate their fans according to volume, speed in revolutions per minute and pressure at which the fan must operate, in addition to the volume to be handled as determined by the formula just given, the engineer must specify the pressure in order to select the proper fan. This may be calculated from the following empirical formula:

$$P = \frac{K S V^2}{A}$$

Where P = the pressure at the fan outlet in inches of water gage or loss of pressure in the duct system; K = constant depending upon material and construction of duct ordinarily assumed as 0.0002 for galvanized iron ducts and 0.00028 for brick or concrete ducts. S = total internal rubbing surface of the duct in sq. ft. V = velocity of the air in ft. per sec. A = area of the cross section of the duct in sq. in. The formula applies only to straight ducts, bends being compensated for by assigning to them an equivalent length of straight pipe, the following values being typical:

Radius of throat divided by diam. of pipe..	0	¼	½	¾	1	1½	2
Equivalent number of diameters of straight pipe	100	67	30	16	10	6	5

Unit Heaters

For use principally in industrial buildings, factories or temporary locations, a combination of heater and fan has been developed which is flexible in application, efficient in heat transmission and particularly effective in giving air circulation and applying heat in sections of rooms where most needed. These heaters may use either steam or hot water circulated through their coils over which a current of air is blown. The coils are usually made up of non-ferrous materials with extended surfaces similar to automobile radiators. Unit heaters may be arranged so as to draw all or a part of their inlet air from outside and thus act as ventilators as well as heaters. They are obtainable in capacities ranging from 450 to 5000 c.f.m. and with heating capacities ranging from 125 to 600 sq. ft. of equivalent direct heating surface. The methods of calculating heat requirements of a building or room to be heated by unit heaters is the same as that given for heating with radiators; unit heaters, however, may be spaced considerably farther apart than radiators, heat being projected to distances of 30 to 200 ft. from the heater with successful installations even 400 ft. apart.

Wherever air for breathing purposes is drawn from outdoors, some means for cleansing it of dirt should be provided. The air filter is the least expensive device for this purpose, the original designs being of cloth stretched over wire netting placed across the intake duct to the building. These become clogged with dirt

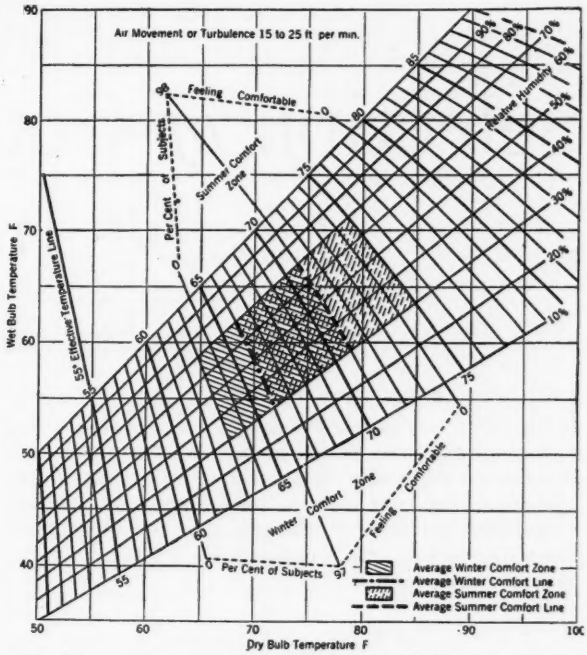


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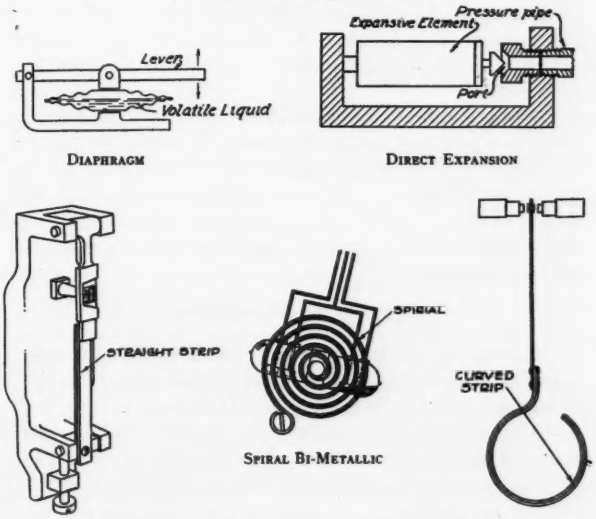
Fig. 4. A.S.H.V.E. Comfort chart for air velocities of 15 to 25 f.p.m. (Still Air)

(Note—Both summer and winter comfort zones apply to inhabitants of the United States only. Application of winter comfort line is further limited to rooms heated by central station systems of the convection type. The line does not apply to rooms heated by radiant methods. Application of summer comfort line is limited to homes, offices and the like, where the occupants become fully adapted to the artificial air conditions. The line does not apply to theaters, department stores, and the like where the exposure is less than 3 hours.)

rapidly, thus increasing the resistance to the passage of air. Impingement types, resembling somewhat steam separators with the baffle surfaces kept wet with oil, are commonly used.

Another form known as the viscous filter employs a layer of metal shavings between two metal screens in convenient size units that can be assembled to cover any size intake. These units are dipped in oil

(Continued on page 428)



(From Chapter 14 A.S.H.V.E. Guide 1934)

Fig. 5. Types of thermostats

Selection *of* Coal *for* Industrial Plants*

By T. A. MARSH**

IT IS WELL KNOWN that much industrial coal is improperly selected, the fundamental cause being lack of proper facts on the part of the purchaser and, at times, on the part of the vendor. Since many industrial plants are burning coal that by unbiased analysis is incorrect for their conditions, it is the purpose of this paper to set forth a rational method of fuel selection for such plants.

What Are Proper Coals?

Proper coal is of course that which gives the greatest fuel satisfaction. Fuel satisfaction must then be defined and the major factors set forth for determining to what degree it is obtainable with any coal.

First must come a tabulation of all the coals available in that market with notes regarding important characteristics, delivered cost per ton and delivered cost per million B.t.u. Few buyers know their entire market and its possibilities, but for a rational selection of coal, the entire list of available fuels must be known. Each of these coals must then be considered in regard to the following:

Primary operation; ability to generate sufficient steam and sufficiently fast to meet load demands; continuity of steam supply, which, again, involves burning characteristics, suitability to grates or stoking equipment, ash fusion temperature, heating value and commercial size.

Economy; the cost based on units of 1000 lb. of steam; for coal, labor, cost of ash disposal, maintenance, capital charges when equipment changes are required.

Supplementary performance; storage properties, tendency to cause smoke, tendency to cause fly ash.

Individual selection; reliability of the selling company; reliability of supply; mine preparation and sizes; ability of producer to provide uniform quality; transportation facilities; engineering services rendered by coal company.

Satisfactory Operation

Taking up each of these considerations, for primary operation the first consideration always is that the plant output be assured. This means that sufficient steam be made sufficiently rapidly and with assurance against shut down. The list of available coals should be marked, indicating what coals can and what cannot be used.

From those coals, selection of the most economical must be made on a unit cost basis.

Steam is simple to measure, either by flow meters as made, or as water entering the boilers. The cost of instruments to measure plant output of steam is reasonable and there is less reason for ignorance of the steam plant output than for that of any other department. Even in industries where the manufactured product serves as a basis for all costs, including fuel, the steam output and its unit cost are necessary for comparison with other known steam costs and for analysis by engineers who know what steam should cost per thousand pounds.

As commonly used, the term "steam cost" is simply the coal cost to evaporate 1000 lb. of steam from and at 212 deg. F. For real analysis, the other items of labor, ash disposal and maintenance must also be included.

Capital charges, interest and depreciation may be omitted from consideration, until such time as physical changes in equipment are contemplated. Then the cost of steam must carry interest and depreciation charges.

Leaving capital charges out of consideration for the moment, a good indicator of the lowest cost usable coal is the delivered cost per million B.t.u. But the final answer is performance, not from a short test, as a 30 or preferably 60-day run should be made on a given coal exclusively, to record costs of fuel, labor and maintenance under actual operating conditions. When the record is complete for each coal, report should be made to the management and purchasing department, with factors applied to each coal indicating what relative price may be economically paid for each qualifying fuel.

Supplementary Performance

Low cost coal will be unsuitable, if storage is involved and the stored coal will deteriorate so as unduly to increase cost or jeopardize the ability to make sufficient steam.

Flashy coals and certain sizes in some other coals are difficult to burn smokelessly, which becomes an objection in many instances. Frequently changes in operation and minor physical changes may make such coals suitable. Here, the engineer of the coal company can be of service.

Usually fly ash is not thought of as a coal characteristic, but coals which cause much fly ash may, in

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certain cases, be objectionable, a matter which is rapidly gaining attention.

Which Individual Coal?

When the three major considerations have been made and coals are known that will carry the load, make low cost steam, and be satisfactory in supplementary performance, selection of the individual coal and the company is a matter resting on the reliability of the supplying company and of the supply, uniform quality, mine preparation, transportation and engineering service. These require no comment but, where larger tonnages are involved, trips to and survey of mines and equipment are evidently warranted.

As to engineering service, it is evident that real engineers should sit in on the determination of the proper coal. Frequently they can suggest changes in operation without changing equipment, or slight physical changes that will make their fuels more suitable and of lower ultimate cost to the user than would be the case without such engineering advice and service. Coal companies having properly qualified engineers are securing tonnage sales unattainable to others, firmly sold and which will probably repeat.

Results of Plant Improvement

To this point, coal selection has been predicated on making no changes in plant equipment. There must be further consideration and analysis of what fuel satisfaction may be obtained, if changes are made broadening the range of fuels usable. These changes bear primarily on cost of steam and may be analyzed on the basis of this one item.

Plant changes require analysis by an engineer. Usually several possible lines of procedure are worthy of consideration, but in each case only one is economically correct. Others, while perhaps beneficial, fall short of giving best plant economy.

In plants limited by equipment to the higher priced coals, the property is not earning what it should and the sooner such plants are changed to low steam cost, the better for them and for the coal companies. Changes should be made, however, only after thorough analysis of steam costs, not on speculative and unsupported guesses.

For investment charges on plant improvements, accountants use figures varying between 13 and 15 per cent to cover the interest and depreciation. Maintenance must be included, also operating charges such as power. Many large industrials will make improvements if they will be self-liquidating in three years, a figure used merely to decide whether to proceed with the improvement. Capital charges must, in any event, be included in steam cost after the improvement is made.

In the financing of plant changes, small stokers (250 hp. developed and smaller) can be purchased from reliable stoker companies in the field on terms in line with the rate of fuel savings effected.

With plant changes, labor cost in large plants may be decreased; in small plants it is usually unchanged.

Finally, financial analysis of the effect of improvements on the steam cost should consider the entire list of coals which may become available.

Coal Characteristics and Fuel Costs

Coal	Characteristics	B.t.u. as delivered	Delivered cost per million B.t.u. cents	Coal cost, cents per 1000 lb. steam based on efficiency of 70%	Coal cost, cents per 1000 lb. steam based on efficiency of 50%
A-	Fast, strong coal	13800	18.98	26.31	37.39
B-	" " "	13500	18.49	25.63	35.88
C-	" " "	14000	18.17	25.18	35.25
D		10500	17.85	24.54	34.35
E-	" " "	13800	17.76	24.40	34.16
F	Quality not dependable	11200	17.41	23.93	33.50
G-	Fast, strong coal	13100	17.13	23.54	32.95
H-	Low ash - Flashy	13500	16.60	23.01	32.21
I+	Flashy, fast coal	12000	14.79	20.48	28.67
J	Slow, inert	11000	14.31	19.83	27.76
K	Quality not regular	11000	14.07	19.50	27.30
L	High sulphur	10500	14.04	19.46	27.24
M	Difficult to store well	11500	13.69	18.97	26.55
N	" " " "	11500	13.69	18.97	26.55
O		10000	13.65	18.86	26.40
P		11500	13.47	18.67	26.13
Q+		10800	13.19	18.28	25.59
R		10800	13.05	18.09	25.32
S		11200	13.95	17.95	25.13

What One Plant Showed

Coming to a specific problem, the plant had two 150-hp. h.r.t. boilers, hand fired, carrying peak load of 250-hp. per boiler. Annual steam output was 40,000,000 lb. or 40,000 units of 1000 lb. of steam. Draft was fair, furnace limited and smoke bad. Operation required the labor of two men, one per shift, at $900 a year each or $1800 total.

In the table are shown the fuels available to this plant. Due to load conditions, draft and furnaces, coals A, B, C, E, G, H, and I were usable, while the rest did not comply with primary operation requirement of ability to make enough steam when hand fired. Thus the low-cost fuels were not usable. Selection of coal was made, after actual trial, of coal I, having 12,000 B.t.u. per pound delivered, at 14.79 cents per million B.t.u. Operated on this coal the plant cost per 1000 lb. of steam was as follows: Coal, 28.67 cents; labor, including ash removal, 4.5 cents; maintenance, 0.1 cent; total, 33.27 cents. Coal used per year was 3234 t. at a delivered price of $3.55, making the annual fuel bill $11,468.

Attention was then centered on those coals offering a lower cost per million B.t.u. Various plans were considered, some elaborate, some rather simple, the decision being for a change to stokers, as this opened a list of low-cost coals with minimum investment, and gave the lowest steam cost, coal, labor, maintenance, operating and financial charges being included.

Contemplated steam cost was based on coal Q, having 10,800 B.t.u. per pound as delivered, costing 13.19 cents per million B.t.u., as this gave some latitude toward use of still lower priced coals. This contemplated cost per 1000 lb. was: Coal, 18.28 cents; labor, unchanged, 4.5 cents; maintenance, 0.3 cent; power, 0.3 cent; capital charges, 15 per cent on $5000, 1.87 cents; total, 25.85 cents. Annual fuel figured as 2568 t. at a delivered price of $2.85, would cost $7312. The actual plant operating costs were within the estimate and a summary of the results obtained was:

	Before	After
1. Tons of coal, annual.....	3,230	2,568
2. Annual fuel bill.....	$11,468	$7,312
3. Cost per 1000 lb. steam.....	0.3327	0.2585
4. Number of thousand pounds steam per year.....	40,000	40,000
5. Total annual gross steam cost..	$13,308	$10,340
6. Investment required		$5,000
7. Annual savings after all charges.		$2,968
8. Period required to pay for changes from savings.....		20 months

It is interesting to note as a side light that, with increased efficiency of stoker firing, the owner could have paid $4.97 per ton for coal I, instead of the market price of $3.55, and still have been even with his old costs. This is mentioned simply to emphasize the thought that stokers enhance fuel values.

The foregoing sets forth the essential items in rational selection of fuel. It represents a service that only a few coal companies are today able to render. For the purchaser it secured the ultimate in low steam cost and fuel satisfaction. For the coal company competent to render such service, it meets the requirements set forth in H. A. Glover's recent treatise; 1. Having something to merchandise; 2. A merchandising plan.

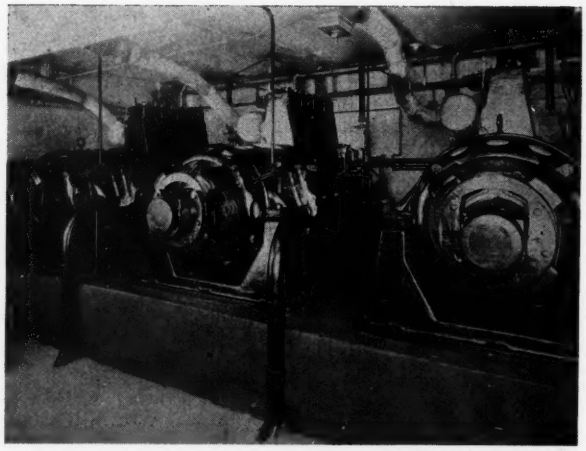
Scale Accumulation in Internal Combustion Engines

By A. E. Hurst
Arctic Chemical & Combustion Engineering Corp.

SCALE FORMATION in the water circulating systems of internal combustion engines cause serious troubles. Research and investigation indicate that more than 70 per cent of the failures due to cracked heads, liners and exhaust valves, are traceable to scale formation on the cooling surfaces. Complete clogging up of the small apertures in the circulating system may even result in bad cases. Scale structures investigated varied from a light carbonate to a heavy calcium sulphate.

Investigation of fresh water cooling systems for marine engines revealed an even more serious condition than scale, i.e., corrosion and pitting. In several cases observed, cylinder walls on the water side deteriorated as much as 0.030 in. in 4 mo. operation. Various formulas are in use for offsetting the acidity of fresh water, in most cases sal soda, sodium hydroxide or potassium. While these chemicals maintain the water in the system in a high state of alkalinity, they sometimes deposit on the cylinder heads and form a hard insulating scale, due largely to the inaccurate measurements of the amount of chemicals. Chemical formulas should be supplied with definite instructions as to dosage for control purposes. These formulas must naturally vary with the type of engine, heat transference and probable water supply.

Systems using salt water circulation present the hardest problem, due to mud, aluminum, silicate and the usual salts in sea water which, especially in the heads and exhaust valves, gives deposits of calcium sulphate which bakes hard due to the intense heat. Various means may be used to dissolve this rock-like substance which has a very high insulating power, one-sixteenth inch of scale being equivalent to approximately 1 in. of magnesium.



The modern Diesel has established a record for reliability both on land and sea. This record should not be endangered by carelessness in regard to the cooling water system

Alkalies, for instance, using sodium hydroxide 70 per cent concentrate act slowly at temperatures from 150 to 210 deg. F. It is, therefore, impossible to dissolve calcium sulphate in the engine, especially in cases where there were small passages that were absolutely blocked making circulation impossible. Tests show that it took from 24 to 72 hr. to dissolve part of this scale using such alkalies.

Aqua regia, a combination of hydrochloric and nitric acid, is more effective. This combination of acids, while they do not attack the calcium sulphate direct, do attack the calcium carbonates. The calcium sulphate structure thus disintegrated broke down and may be washed from the circulating system. It is necessary due to the highly corrosive action of these acids to place inhibitives in the chemical compound to prevent attacking the ferrous and non-ferrous metals.

This combination has been tried out over a period of 3 yr. on passenger ships and some of the largest Diesel engine tankers. The outstanding feature of the use of this combination is that the work is done cold and is performed in a few hours, so that it does not delay the ship or interfere with the port operation. Calibrations of various parts of the engine after using this cleaning combination for a period of 3 yr. have definitely proven that there was no corroding of the metal, fatiguing or general deterioration.

In all cases where this scale removal process is undertaken, a sample of the scale should be taken from the engine and thoroughly analyzed in a laboratory to definitely determine whether the formation can be broken up. Cases have come to light where it was necessary, with a calcium sulphate structure, to completely saturate the system with CO_2 gas to increase the carbonates. After this the acid combination will dissolve the carbonates and thus softened the structure may easily be washed out.

Don't Use Shunts *with A. C. Instruments*

By E. H. STIVENDER

The use of shunts with direct current instruments is so well known and seems so simple that the question often is raised, why not use this same principle of measurement on A. C. circuits. In this article Mr. Stivender tells why this is impractical

ON VARIOUS OCCASIONS the supposition has been voiced to the writer that the calibration of an alternating current instrument might be changed satisfactorily by the use of shunted resistance in the current circuit. This illusion is usually brought about by the known fact that current transformers are indispensable on higher voltage circuits due to the insulation they offer between the instrument and power circuits; hence other reasons for their use are likely to be overshadowed and may remain obscure to a person unless the operating principles of shunts and current transformers is brought to mind.

Metering of large direct currents is accomplished by measuring the milli-volt drop across a shunt, that is, a direct current ammeter for large currents is in reality a milli-voltmeter. The resistance temperature coefficient of the shunt being low, this IR drop is very approximately proportional to the power current flowing. From this we can see that in order to measure large direct currents, a certain amount of power is expended in the shunt. For instance, a 15,000 amp. 100 milli-volt shunt requires 1.5 kw. when operated at capacity.

In the measurement of large or high voltage alternating currents when using current transformers, practically all the voltage present is the IX drop of the instrument, the slight power loss being that due to iron and copper losses in the current transformer and leads; hence, theoretically, there should be no power lost in the measurement of alternating current with current transformers, while there necessarily must be a power loss where shunts are used, as on direct current circuits. A. C. meters and relays are of very low resistance and capable of handling large circuits.

Principles of Shunts

Since the shunt is a device for producing a voltage drop, the instrument used with it must have leads of known resistance and must be properly calibrated with respect to this value. Additional instruments cannot be operated in parallel with the original instrument from a single set of leads with any satisfactory degree of accuracy unless all the instruments, including the original one, are recalibrated with respect to the greater milli-volt drop in the leads. The usual practice where more than one instrument is operated from one shunt is to provide an independent set of leads from the shunt to each instrument, thereby eliminating the effect of a greater milli-volt drop in one set of leads.

Where shunts are used, part of the power current flows through the instruments, being only a few milliamperes for the usual indicating meters and relays, but this fact causes an error in the readings when additional instruments are added, even where individual sets of leads are employed. The error is negligible where the shunt has a relatively high rating compared to the current capacity of the instruments. This is usually the case with shunts of 10 amperes rating and over. As the total current capacity of the instruments approaches that of the shunt, the condition is approached where more current flows through the instruments than through the shunt, hence the shunt current can no longer be regarded as even approxi-

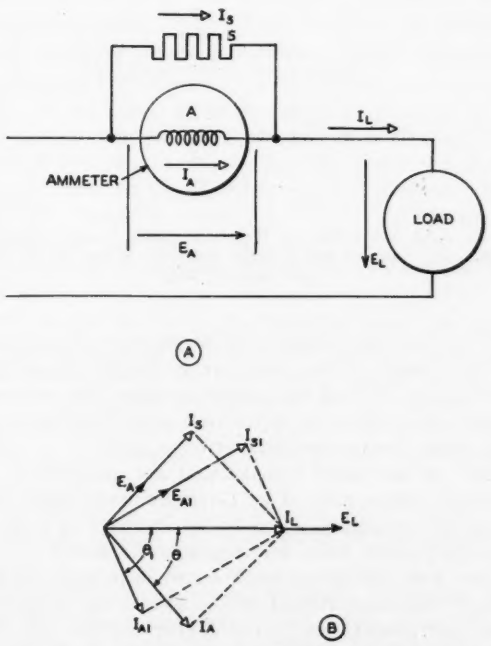


Fig. 1. (A) A. C. Ammeter Circuit Using a Resistance Shunt. (B) Current and Voltage Relations in the Circuit of (A)

mately all the current flowing, and very incorrect readings result, owing to the instruments measuring the IR drop of the shunt as well as that of themselves.

The great difference in the principles of operation of shunts and current transformers is that the former are devices of constant potential character; that is, for a given current flowing, a reasonable number of instruments may be added in parallel without appreciably affecting the milli-volt drop across the shunt, while the current in the instrument circuit increases with the number of instruments. Current transformers are constant current devices. All instruments must be in series, and, with constant primary current, the secondary e.m.f. increases with the number of instruments used while the current remains the same or sufficiently so as not to appreciably affect the readings.

In order to furnish the e.m.f. required to overcome the IX drop of the instrument circuit, part of the primary circuit is in quadrature with the primary e.m.f. and the instrument current, being the magnetizing current of the transformer. It is proportional to the reac-

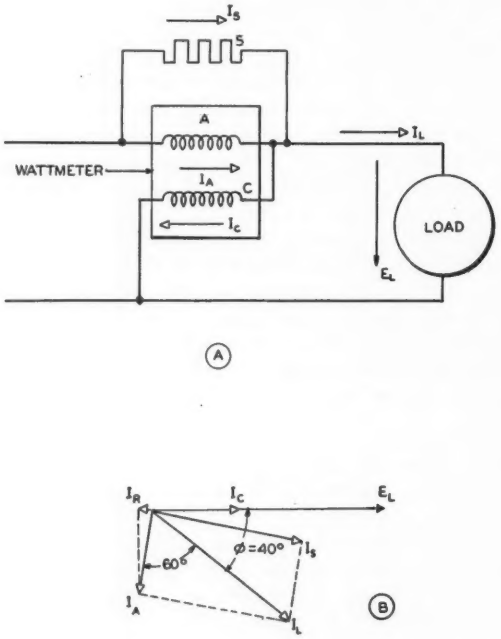


Fig. 2. (A) Wattmeter or Watthour Meter Using a Resistance Shunt. (B) Current and Voltage Relations When the Load Current Lags 40 Deg.

tive drop in the primary, which in turn depends upon the impedance of the instrument circuit; hence as the volt-ampere load of the secondary rises, the secondary current does not bear its turn ratio to the primary current, since the magnetizing current appears in the secondary as increased voltage and not as current; it is therefore not measured by the instruments and causes an error in readings. Due to the increase in magnetizing component with an increase in secondary volt-ampere load, the phase angle between primary and secondary is also greatened, which affects the accuracy of such instruments as power factor meters and watt-meters.

For the above reasons, standard current transformers are usually "compensated" for a specified volt-ampere load. This is done by adding turns to the secondary so as to decrease the magnetizing current required for a given IZ drop. The error therefore appears when the transformer is operated above or below this compensation rating; but over the average operating range the error is below that of an uncompensated transformer.

If the secondary of a current transformer is opened while fully loaded, the secondary e.m.f. greatly increases, and were it not for saturation of the iron, it would reach the high value determined by the frequency and the primary current, which would be practically all magnetizing current in this case. Under this condition, if the insulation does not break down to allow secondary current to flow, the transformer will likely be burned up due to the increased iron losses. Secondary voltage on open circuit is limited by saturation, but this does not keep it from reaching destructive values.

Action of Shunts in A. C. Ammeter Circuits

Since we have noted the difference in shunt and current transformer principles, we will now examine the conditions when shunts are used in connection with several kinds of a.c. meters.

In Fig 1 (a) is the elementary circuit of an a.c. ammeter. Assume it is desired to reduce the ammeter current to one-half its value by the addition of shunt S. On a direct current circuit this would be accomplished by making the shunt of exactly the same resistance as the ammeter coil. In Fig 1 (b) is illustrated vectorially the effect of adding a shunt of the same impedance as the ammeter in an a.c. circuit. The load current is assumed to be of unity power factor for convenience; hence load current I_L is in phase with load voltage E_L. The shunt is all resistance, while the ammeter can be considered as all reactance. The load current I_L is then the sum of the two equal quadrature components I_S and I_A, I_S being in phase with e.m.f. E_A, and I_A lagging it by 90 degrees. In this case, current I_A is not one-half I_L, but is $1 \div \sqrt{2} \times I_L$, or $0.707 I_L$. In order to make the ammeter current equal to $0.50 I_L$, I_A must lag by an angle θ, so that $\cos \theta_1 = 0.50$. This angle of 60 deg., which means the shunt must be of such a value that its current is I_{S_1}, leading I_L by $(90° - 60°)$, or 30°. The ratio of I_{S_1} to I_{A_1} must be $\sin 60° \div \cos 60°$, and since the current varies inversely as the resistance, or vice versa, the ratio of shunt impedance to ammeter impedance must be $\cos \theta_1 \div \sin \theta_1$ or $0.50 \div 0.866$. The shunt impedance is then 0.577 times the ammeter impedance, instead of equal to it as in a direct current circuit.

The above will work out satisfactorily provided the frequency remains constant; but where erratic frequencies prevail, this connection is entirely unsatisfactory. Should the frequency decrease, the current of the ammeter would increase due to the change in reactance. This would cause a decrease of shunt current. Let us examine the error produced under such conditions when the frequency drops 20 per cent. Where the ratio of shunt impedance to ammeter impedance was $0.50 \div 0.866$, it now becomes $0.50 \div (0.866 \times 0.80) = 0.721$) the frequency is now 80 per

cent). The currents being the inverse of the impedance, the ratio of shunt current to ammeter current is 1÷0.721, or 1.385, where it was formerly 1.732. Since $I_{S1} \div I_{A1} = \tan \theta_1$, than $\tan \theta_1 = 1.385 \div 1$ or $\theta_1 = 54.2°$. I_{A1} is $\cos \theta_1 \times I_L = 0.585 I_L$. I_{A1} was formerly $.50 I_L$, and if the ammeter has been calibrated to take $0.50 I_L$, the error is 17 per cent higher reading than actual current flowing.

Action of Shunts With Power Factor Meters

The utter futility of using a resistance shunt in connection with a power factor meter is apparent by examination of Fig. 1(a). The presence of a shunt used under such conditions caused the meter current to lag 60° when the load was of unity power factor. Frequency variations introduce considerable error, it has been pointed out that a drop in frequency of 20 per cent causes the phase angle to change from 60° 54.2°, when the shunt is adjusted for the meter to take one-half load current.

Action of Shunts on A. C. Wattmeter Circuits

If a resistance shunt is used with an A. C. wattmeter, the phase angle within the meter will not only cause considerable inaccuracy, but changes in load power factor will contribute to great errors, causing the meter to reverse at times.

This can be seen by examination of Fig. 2. Current and potential transformers are excluded from these diagrams for simplicity, since they do not affect the discussion. The value of shunt S is chosen to make one-half the load current go through the wattmeter or watthour meter current coil A. Since wattmeters and watthour meters are made to read the value of EI cos ϕ, even though in watthour meters the potential coil flux is at right angles to the line potential, the vector diagram of Fig. 2(b) holds for both kinds of meters, and we say that potential coil current I_C is in phase with E_L at all times.

At the frequency for which the value of the shunt resistance is chosen, the current I_A of the wattmeter series coil lags I_L by 60°, as shown in Fig. 2(b) and was explained previously for the ammeter circuit of Fig. 1(a); hence when the load power factor is cos 30°, that is $\phi = 30°$, I_A lags I_C by $30° + 60° = 90°$, and the wattmeter indicates EI cos 90° = 0, regardless of the magnitude of actual load current I_L. Should ϕ become greater than 30°, say 40° lagging, I_A lags I_C by 100°, as indicated in Fig. 2(b), and its component I_R acting with I_C to produce indications is reversed, making the wattmeter read EI cos 100° = —1.736EI. The negative sign means reversed torque on the meter element. Frequency changes cause angular variations as well as magnitude variations of I_A, as in Fig. 1, and affect the readings in accordance with these values.

Impedance Shunts

Obviously the only way to correct such a condition without resorting to the use of a current transformer would be to construct the shunt so it has the L/R value as the instrument, thereby making a change in frequency cause corresponding changes of reactance in shunt and ammeter alike. Such a procedure is feasible; however, it would probably be easier to construct and install a current transformer than to properly calibrate an impedance for the purpose, for when making such an impedance, it is necessary that the slight resistance present in it be of the same temperature coefficient as that in the meter, also the shunt should be placed in the same room with the meter in order to avoid errors due to difference in ambient temperature, otherwise conditions somewhat comparable to that outlined above for a straight resistance shunt may develop.

In summing up, we can say that shunts are adaptable only to d.c. circuits, and current transformers only to a.c. Also that were it possible to operate transformers on d.c., their use would be preferable to shunts.

Safety Pointers for Heating Boilers

After an exhaustive investigation of emergency low water feeders for cast-iron and steel heating boilers, the Engineers Conference of the Boiler and Machinery Department of the National Bureau of Casualty and Surety Underwriters has prepared standard requirements for the construction of such emergency low water feeders which it recommends to manufacturers and users of such equipment.

This, it is announced, is in no sense a definite ruling but represents recommendations based upon the results of many years of broad experience and the investigation of the cause of a large number of failures and accidents. The recommendations are as follows:

The water inlet valve to be separate from the float chamber and sufficiently isolated or insulated from the heat to insure a temperature at which scale will not be deposited.

The float to be of rugged construction and to have a displacement equivalent to a sphere 5 in. in diameter.

The bearings, pins, water valves and their seats and other moving parts to be of non-corrosive material.

All parts to be readily accessible for inspection, cleaning and repair.

To be provided with a blowoff connection to the float chamber to facilitate the removal of deposit in the float chamber, and to permit testing the device without lowering the water level in the boiler. Such blowoff connection should be either an independent connection to the float chamber or a connection in the water line to the feeder immediately below the float chamber.

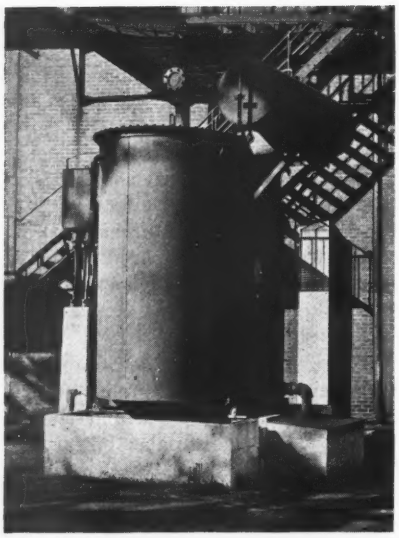
The device to be set to function when the water level in the boiler is 1 in. above the bottom of the gage glass, assuming that the gage glass is set at the proper level and to be of sufficient capacity to maintain that water level when the return valve or valves are closed and the boiler is operated under the most forced conditions of firing.

The device to be so connected that it will feed through the regular feed connection and not the water column.

Recommendations relate to those emergency low water feeders installed on boilers which are used for the heating of residences, apartment houses, office and similar buildings.

Choosing large STARTING EQUIPMENT *for* SYNCHRONOUS MACHINES

BY H. R. STEWART, ENGINEERING DEPT.
WESTINGHOUSE ELECTRIC & MFG. CO.



16,240 kv-a. Combined Grounding and Starting Autotransformer

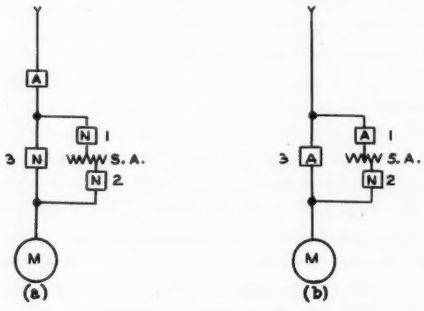
IN THE CHOICE of starting equipment for modern large synchronous motors or condensers, two methods are available in general, namely, the "open circuit" method shown in Fig. 1, and the "closed circuit" method shown in Fig. 2.

So far as desirability from the point of view of bump on the system and stress on the machine is concerned, both schemes are satisfactory, and therefore the choice between the two is usually based purely on relative cost of equipment and connecting cables rather than on engineering considerations. However, a special case recently arose where it was necessary to give very careful consideration to the engineering features in making a choice, and where the relative cost was of secondary importance.

The case in point was where a 12,850 kv-a., 70 per cent power factor, 1800 r.p.m., low transient reactance, salient pole, parallel rotor slot, steam turbine driven generator about 20 yr. old was to be disconnected from its prime mover, and operated for sound economic reasons as an 11,000 kv-a. synchronous condenser for purposes of power factor correction, voltage control, and station heating. In order to save the expense of a separate starting auto transformer, it was desired to make use of taps on a 16,240 kv-a. grounding transformer which was to be connected to the same bus. With this complication the question arose as to whether to build this grounding transformer for starting the condenser by the open circuit or "closed" method, circuit connection diagrams for which are shown respectively in Figs. 3 and 4, for this particular case.

On first rough analysis it was felt essential on account of the age and very low reactance of the machine to start it by the second method, since this carries the apparent advantage that during the transition from starting to running, the machine is never completely disconnected from the power supply, and therefore would be expected to undergo less danger of a severe bump from synchronizing current inrush when the running breaker is closed than if the open circuit scheme is used. As the name implies, in the open circuit scheme the machine is totally disconnected from the power supply during the transition and during this period is free to drift out of phase with the bus voltage.

However, the "closed" scheme entails the disadvantage in this particular case that if the transformer is built with sufficiently low reactance in the series part of the winding to pass any adequate amount of



A — AUTOMATIC BREAKER
N — NON-AUTOMATIC BREAKER
S.A.— STARTING AUTO, SIX LEADS BROUGHT OUT
M — MACHINE

STARTING SEQUENCE	
CLOSE	1 & 2
APPLY FIELD	
OPEN	2
OPEN	1
CLOSE	3

Fig. 1. One line diagram of open circuit starting, no disconnecting switches shown. Machine is completely disconnected from power supply between opening of 2 and closing of 3

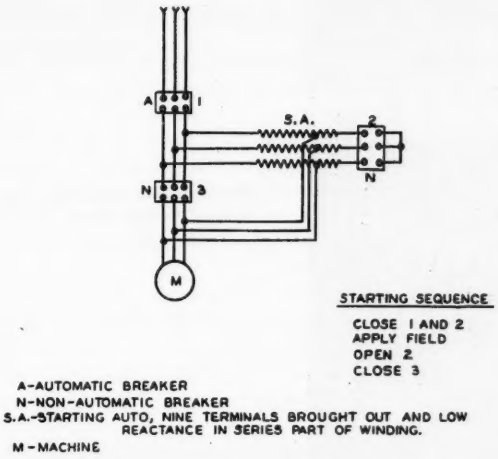


Fig. 2. Three line diagram of "closed" starting method, disconnecting switches not shown. Between opening of 2 and closing of 3, machine is still connected to power supply through the reactance of the series part of the starting transformer winding as a reactor

current to the machine to hold it in step during the transition from starting to running, the transformer would draw a high magnetizing current from the bus as a grounding transformer at all other times and thus tend to neutralize the leading current drawn by the condenser. For example, if the transformer were built with maximum allowable series reactance to make the closed circuit transition of any benefit, namely, about 1000 per cent reactance on 12,850 kv-a. base, it would draw approximately 1250 kv-a. at practically zero power factor lagging from the bus at all other times, thus rendering the 11,000 kv-a. condenser effective only to the extent of 11,000 — 1250 or 9750 kv-a. overall, when operating.

This drawback encouraged closer scrutiny of the open circuit scheme to see just what angular drift was possible during the open circuit transition. This drift results from the slowing down of the condenser caused by friction, windage, and core losses on open circuit, and was calculated to be 6½ electrical degrees if not more than ½ second elapsed between the opening of the starting breaker contacts and the closing of the

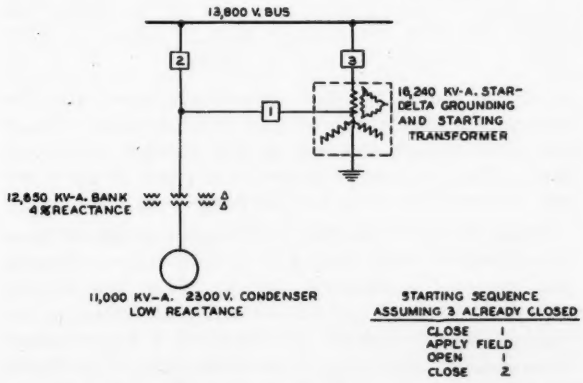


Fig. 3. Single line diagram for starting 11,000 kv-a. condenser by open circuit method from taps on a 16,240 kv-a. star-delta grounding transformer. Consider the condenser and its associated step-up transformer as a 13,800 v. unit. Machine is completely disconnected from power supply between opening of 1 and closing of 2

running breaker contacts. It was found that the breakers could be adjusted to operate in this time. On the other hand, the angle between the bus voltage and the high voltage terminals of the 12,850 kv-a. transformer bank, subtended by the reactance drop across the series part of the starting transformer winding in the "closed" scheme, amounted to 25 deg. at the end of the transition period. Thus in this particular case it worked out that the machine would actually be subjected to less bump when the running breaker closed on open circuit starting than on closed circuit starting. Accordingly, the former was adopted.

Other advantages accompanying this choice in this special case was that it eliminated the transformer neutral breaker, avoided a temporary removal of the ground during the starting period, and reduced the cost of the combined grounding and starting transformer by about 40 per cent, and its magnetizing current from 10 per cent down to 0.4 per cent.

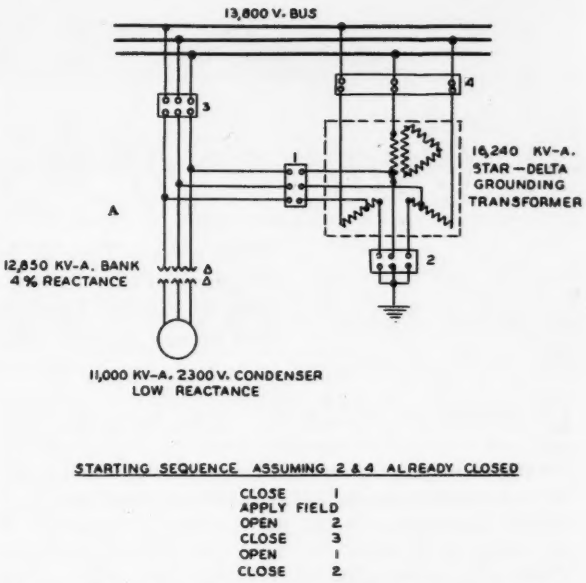
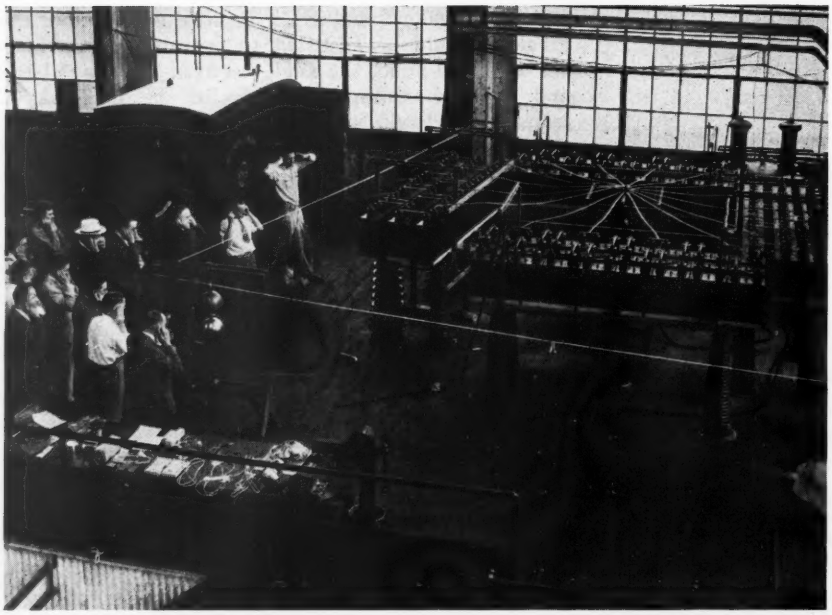


Fig. 4. Three line diagram for starting 11,000 kv-a. condenser by "closed" method, using taps on 16,240 kv-a. star-delta grounding transformer. Consider machine and associated step-up transformer bank as a 13,800 v. unit. Machine remains energized through reactance of series part of grounding transformer primary between opening of 2 and closing of 3, and voltage drop in this reactance develops a phase angle between bus voltage and voltage at point A

The equipment has now been in successful operation for almost two years. Acknowledgment is made to the engineers of the Stone & Webster Engineering Corporation, and Blackstone Valley Gas and Electric Company for their joint efforts in working out the more satisfactory of the two starting schemes.

DIESEL ENGINES up to 10,000 hp. are now available from Busch-Sulzer Bros. Diesel Engine Co., of 2-stroke cycle type with 12 cylinders 30 in. diam. by 52 in. stroke. Trunk pistons are used, the important castings being of nickel cast iron, especially the cylinder liners. In trials of a 3-cylinder engine of this type for marine use, 800 brake horsepower maximum was developed per cylinder. Fuel consumption was 0.36 lb. per gross horsepower-hour at half load.



Engineers watching high ampere generator about to discharge.

A *Quarter of a Million* Amperes

With a New Type of Impulse Generator, Electrical Engineers Have Produced a Current Equivalent to that of Natural Lightning—a Current that Vaporizes Heavy Copper Wire, that Smashes Concrete

ELECTRICAL ENGINEERS, who for years have had at their command pressures of millions of volts, now have produced a current that is of the same order of magnitude as that in a severe direct stroke of natural lightning. In the high voltage laboratory of the General Electric Company at Pittsfield, Mass., where man-made lightning bolts of 10,000,000 v. were first attained, the engineers have produced discharges of approximately a quarter of a million amperes.

Just as natural lightning, with amperage approaching this figure, destroys that which it strikes, so does the laboratory discharge; and just as natural lightning is accompanied by deafening thunder, the laboratory discharges have their ear-splitting crashes that reverberate through the large building.

The current now available at Pittsfield, far greater than that hitherto found in any laboratory, is being used by K. B. McEachron, engineer of General Electric's high-voltage laboratory, and his staff in the study of methods for protection of electric and other equipment against lightning—work that in itself does not appear spectacular to the layman visiting the laboratory. There are, however, many impressive experiments that can be conducted with the new equipment.

Approximately a quarter of a million amperes are discharged at a pressure of 150,000 v. in eight microseconds (eight one-millionths of a second), and more than 30,000,000 kw. are represented in a single discharge.[1]

A copper wire a tenth of an inch in diameter is completely vaporized in the few millionths of a second required by the discharge. A similar piece of iron wire is "exploded," the remaining ends of the wire remaining white hot for several seconds. A section of reinforced concrete is broken into bits, just as a concrete structure is shattered when struck by natural lightning. A silver-plated iced-tea spoon vanishes with a shower of sparks, only the bowl of the spoon, discolored by heat, remaining. Metallic armored (BX) cable is destroyed, or may be ignited.

If the arc is confined in a small fiber tube, the tremendous pressure developed will blow the tube to bits, even though it has a wall a quarter of an inch thick. The pressure will shatter a pane of glass several inches away when the discharge is in open air.

Even though a conductor is heavy enough to carry the current without fusing, it is subjected to tremendous internal mechanical forces. When the current is passed through a flat copper strap, for instance, the "pinch effect" crumples the strap to a nearly round cross section. Similarly, if two iron wires, of sufficient diameter so they will not be exploded by the discharge, are bent apart an inch or so in the center, the "pinch effect" will pull them together with such force that they will be flattened where they strike each other. To carry such a heavy current continuously without

[1]This is approximately equal to the entire installed capacity in all the steam central stations in the United States.—Editor.

overheating would require a solid copper conductor 3 ft. in diameter.

So explosive are the discharges, it is necessary to confine most of the experiments within sturdy protecting cylinders, making it impossible to see the intense flash of light as the discharge takes place. There is no difficulty in hearing it, however. Observers in the laboratory find it necessary to plug their ears with cotton or to clamp their hands over them, just as do men standing near big guns.

The visitor to the high-voltage laboratory in Pittsfield where the previously developed 10,000,000-v. generator is installed is impressed by the magnitude of the equipment. Maximum clearances are essential in handling such voltages, so the equipment is of towering proportions. In decided contrast, the new

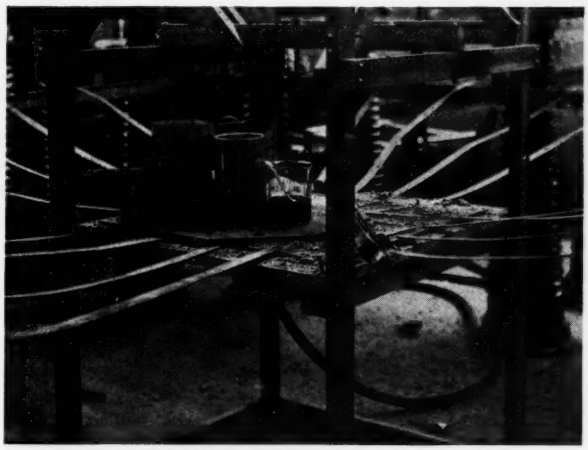


Fig. 1. High current generator with cans, glass beaker and spoon before tremendous charge is released.

high-current generator occupies a minimum of space. In fact, the success of the engineers in obtaining such an enormous current output with a minimum of equipment is the result of the application of new principles of construction, producing a compactness never before achieved with such equipment, with resulting increased efficiency.

Ninety-six Pyranol-filled capacitors are arranged in a hollow square of 88 in. inside dimensions, 4 ft. above the floor on a wooden platform resting on insulators. Each side of the square contains 24 of the capacitors, arranged three across and eight along the side; and one side of the square is pulled out at one end to permit the operators to enter the enclosure. The individual capacitors, measuring 14 by 9 in. and 21½ in. in height over their bushings, are rated at 50,000 v. each.

Each three capacitors in the width of the installation are connected in series to produce 150,000 v., and the 32 such banks of units are connected in parallel. Heavy copper straps lead from the banks to a large copper plate in the center of the hollow square, about two feet above the floor, and to the uppermost of three spheres above this ground plate.

The outermost spheres are a sufficient distance apart to hold the 150,000-v. charge; the middle sphere is used as a trigger to set off the discharge at the proper moment. As set up in the laboratory, the middle sphere is tied in with a cathode-ray oscillograph, so that the discharge can be effected at the proper instant for operation of the oscillograph.

The generator is charged from the ordinary 110-volt, 60-cycle circuit. This is stepped up to 75,000 v. by means of a transformer and then doubled and converted to direct current of 150,000 v. by two Kenotron rectifiers in series. About one-half minute

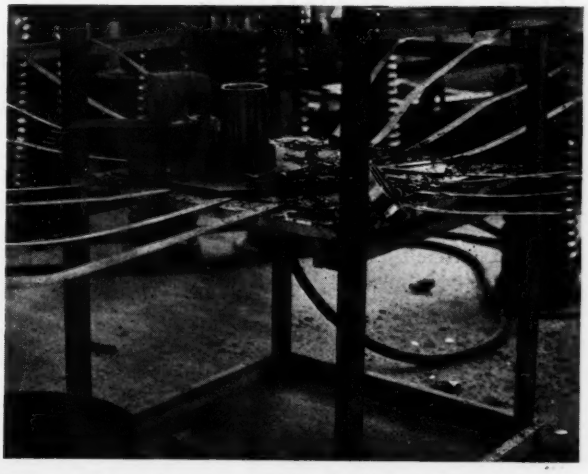


Fig. 2. Shattered remains of glass beaker, punctured cans and dented spoon after charge is released from high current generator.

is required to charge the capacitors, there being a heavy initial rush of current when the charge is started and a slowing down in rate as the charging time progresses.

The Pittsfield laboratory is entirely devoted to research and developmental work in connection with the transmission and distribution of electric energy, the ultimate purpose of this work being the prevention of power interruptions and the improvement of electric service. The laboratory investigations with artificial lightning are supplemented by studies of natural lightning in the field, and field laboratories are operated during the lightning season in sections of the country where lightning is especially prevalent.

FORCES WORKING for wider distribution of the national income are evidenced by data given by the National Industrial Conference Board. From 1929 to 1932 most large business organizations were paying out for wages more than their income, thus distributing from their surplus or reserve capital. During 1932, for trade, i.e. buying, distributing and selling, this loss was 3.5 per cent above income; for manufacturing, it was 18.5 per cent over; for construction and building 51.8 per cent.

During the 3-yr. period, while national income fell off 52.6 per cent, the part paid for labor decreased only 40.3 per cent, and that used for other purposes decreased 74.1 per cent. For 1929 the part of national income going to labor was 63.6 per cent, while for 1932 it was 80.1 per cent. In addition, of dividends and interest paid to those with incomes under $10,000 a yr. the decrease from 1929 to 1932 was only 7.7 per cent, while payment to those with larger incomes fell off 67.1 per cent.

Hydroelectric Station *Flies* into wilds *of* New Guinea

Complete equipment for 3500 kv-a. Station Flown 40 Miles by Huge All Metal Freight Planes

COWS have jumped over the moon and a winged Pegasus has switched his equine tail among the clouds, if one takes song and fable literally, but this is the first time that a hydroelectric generating station has taken to the air and gone places on wings. No song, no fable, no myth, but an actual occurrence.

Four General Electric horizontal waterwheel generators, rated at 875 kv-a. each, together with associated apparatus, left San Francisco on May 1 aboard the S. S. Carisso bound for Lae on the coast of New Guinea—an island larger than Texas lying north of Australia and almost touching the equator. At Lae, the equipment was loaded, one section at a time, into huge all-metal Junkers freight planes and flown 40 mi. inland to the headwaters of the Bulolo River, where Bulolo Gold Dredging, Ltd., has established a thriving placer mining camp.

After gold had been discovered in this region in 1925 and the richer veins worked out by prospectors using hand methods and packing their "take" out through the jungle on the backs of natives, it became evident that placer operations on a large scale would pay if the necessary dredges and other machinery could be gotten in.

Transportation, however, was a serious problem—an almost insurmountable obstacle, in fact. The distance involved was not great, but the terrain consisted of dense, nearly impassable, and cannibal-infested jungle, together with a mountain range whose peaks rose to 13,000 ft.

Finally, the pilot of an airplane sent in to investigate the feasibility of using air transport was able to land his ship close to the site of proposed operations. This opened the way and a flying field was subsequently cleared off and levelled to accommodate large, heavily loaded planes.

Then began the slow process of flying in, piece by piece, specially designed mining equipment, including two large dredges. Reducing the size and weight of some parts of the heavier equipment until the planes could handle them presented a nice engineering problem—but the job was done and mining operations, which are proving very successful, commenced. The big Junkers freight planes handle all material going in or coming out—routine shipments or those connected with the further development and expansion of the project.

These ships have a load limit of 7000 lb., their hatchways measuring 140 in. by 60 in. with a normal inside height of 70 in. The cabins, which are 24 ft. long and have a minimum height of 4 ft., will accommodate any long narrow packages up to 24 ft. in length which can be threaded through the hatches. All packages, however, must be small enough to leave a one-foot clearance all around.

The four G-E generators rated, as stated above, at 875 kv-a. each, are designed to operate at 11,500 v., 50 cycles, at 600 r.p.m.. The largest single pieces of these machines are their stators, which have a net weight of 6545 lb. Boxed for shipment, the stators measure 82 by 49 by 97 in. Because of the small margin between their weight and the load limit of the planes, and because of limitations in loading dimensions, it is readily apparent that most of the boxing, if not all of it, must be removed and special skids prepared before the stators can be flown to the mining camp. The fields for the generators weigh somewhat less than the stators and have more favorable dimensions.

Other apparatus shipped by the International General Electric Co. to be associated with the generators in equipping the Bulolo hydroelectric station, include a complete switchboard, a Trumbull power and lighting board, several small lighting transformers, and a 60-cell storage battery. None of these, however, offer a problem for the planes as they can be readily separated into small units of relatively little weight.

Not Water Wheels

NO, THESE CONTRAPTIONS are not water wheels; they are fish screens installed in irrigation ditches, tailraces, tunnels, etc., to keep salmon in their migrations down stream from passing into forebays (and thence through turbines of power plants where they would be killed)

Rotary self propelled fish screen

or into irrigation ditches (and thence on to the land where they would die).

The type of fish screen shown in the accompanying photos is known as the rotary self-propelled type and consists of steel shaft to which there is attached a circular frame which supports mesh of ½ to 6 in. with boards or paddles set on the inside which furnish the motive power for its rotation. This screen is set in a box of supports for the entire width to be screened. To pass the trash that may come down or to remove the moss, it is set up from 4 to 8 in. from the bottom of the ditch and connected by rods to a spring, so that when the pressure of the trash becomes more than the tension of the spring, the board or draper will drop down sufficiently to pass this trash and then come back into place.

Automatic Gas Fired Boiler *furnishes Steam for* Ford Exposition Building

AT THE EXTREME south end of the Ford building at the Century of Progress Exposition in Chicago is a museum which houses a replica of Ford's first workshop, a typical machine shop of many years ago operated by a steam engine built in 1842. Another steam engine in the same room operates one of Edison's first dynamos, built in 1871, which furnishes light for the old Ford workshop. The steam for operating these engines as well as for operating a modern glass plant and rubber plant at the extreme other end of the building is furnished by a modern steam plant installation housed in the museum.

Gas was selected as the fuel to operate this plant because of its cleanliness and its ability to respond quickly to wide variations in steam demand. The boiler is of the horizontal fire tube type with a nominal rating of 80 hp. and with 1813 sq. ft. of heating surface. The gas burning equipment on the boiler setting was provided to operate this boiler up to 200 per cent rating, steam maintained at 150 lb. pressure. Great care was taken in the setting of this boiler to provide proper insulation so as not to overheat the room in which it is installed; also to provide maximum efficiency at all times.

The gas burner employed is of the ring type and is located within a ring shaped air register in such a position that a central stream of air whirls through the inside of the burner ring and an outer stream of air whirls through the venturi on the outside of the burner ring. With this arrangement the gas is actually induced into the furnace which insures complete combustion without high gas pressure and also keeps the gas burner parts cooled by the inner and outer streams of air. The gas burner ring is adjustable backward and forward in relation to the venturi ring allowing a wide range of flame regulation. This adjusting can be done while the burner is operating. The gas ring is hinged so it can be swung back out of the firing position for inspection or replacement.

The air register surrounding the burner consists of a fixed and a movable sleeve with rectangular ports cut through both sleeves. The outer sleeve is actuated by a rack and pinion which moves it circumferentially to close or open the ports. The handle operating this pinion passes over a quadrant with an adjustable stop so that after finding the correct position it can be locked. Two 2-in. gas lines, one on either side of the gas ring, provide an even distribution of gas. A flexible gas hose connects the burners to the main gas line so that no connection need be broken to swing the burner out. An additional hose connects the pilot and is a separate line taken off ahead of all controls. This burner is 27 in. in diameter and fires through a special venturi tile lining.

The gas burner is provided with a control system set to maintain a steam pressure of 150 lb. The primary controler is a "pressure-stat" built along the principle of a Wheatstone bridge which, through a reciprocating damper motor, coördinates the stack damper setting with a motor operated gas valve in the gas supply line to maintain the correct steam pressure with an unvarying air-gas ratio. This control system will come to rest at any point along the line when the correct balance point between steam pressure and fuel flow is attained. (This varies from the ordinary method of high-low control which has but two fuel flow settings, one high and one low and alternates between.)

The advantages are two-fold, first, it prevents overshooting and undershooting of the required steam pressure, and, second, it provides greater economy of fuel consumption by eliminating sudden changes in the rate of firing. An additional "pressure-stat" cuts off the fuel supply entirely in case of excess steam pressure (above a 5 lb. margin). Also a low water safety shuts off the gas fuel flow in case the water level drops below a predetermined point.

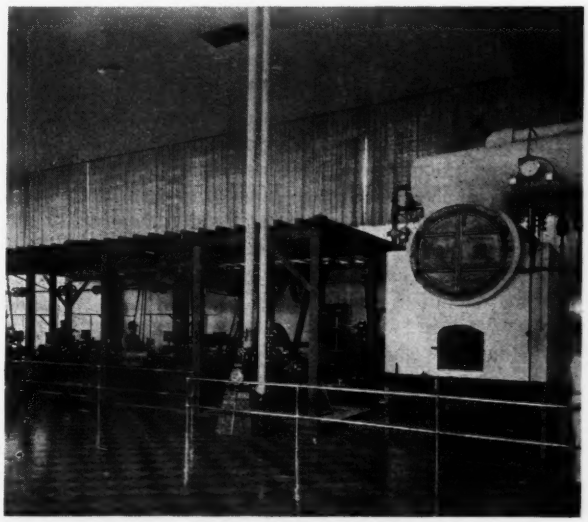


Fig. 1. View showing old Ford workshop and modern gas fired boiler

Great care has been taken to provide safe ignition and operating period. An electrode-relay system is used for which the main burner flame acts as a switch arm to close an electrical circuit. A small gas pilot is maintained continuously but is not in contact with the electrode-relay. To start the main gas burner the small pilot flame is lengthened sufficiently, through a push button valve, to insure safe ignition of the main burner.

This pilot, thus momentarily expanded, makes contact with the electrode-relay completing a circuit to a second motor operated gas valve placed in the fuel line ahead of the modulating control valve. A second

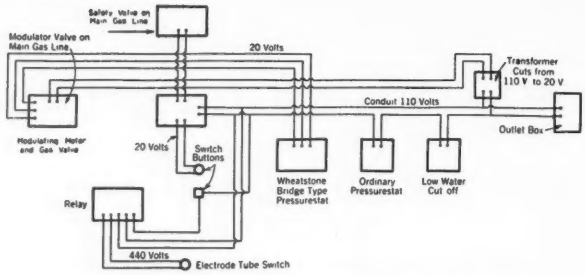


Fig. 2. Schematic diagram of electrical control system

push button opens the main body of the fire and is released as soon as the main body of fire makes contact with the electrode-relay. (Both buttons are operated by hand against springs.) The gas pilot then returns to normal size and out of the path of the safety control or electrode-relay, making the continuous operation of the system entirely dependent upon the continuity of the flame from the main burner. Any momentary interruption of this flame automatically cuts off the gas supply and renders the system dead. All safety controls must be manually reset before operation can be continued.

Thermionic Tube in Control System

The term "electrode-relay system" refers to the combination of electrode, tube and relay.

In this system, an electrode is mounted so that it extends into the flame of the main burner. The flame completes the electrical circuit of a grid glow tube relay system. The circuit is so arranged that when an electrical path is completed from the electrode to ground, the relay closes its contacts. When this electrical path is interrupted, the relay opens its contacts.

The use of a modulating control system of the above type in which the stack damper setting is coördinated with the opening of a gas valve is, of course, predicated on constant gas pressure ahead of the control system and constant breaching draft on the stack side of the damper. A gas governor takes care of the former and a barometric draft regulator at the stack provides the necessary constant draft. In this way the air-gas ratio of the combustion efficiency remains practically constant throughout the full range of boiler output.

Heating and Air Conditioning Equipment

(Continued from Page 415)

that adheres to the metal shavings and catches the dust as it enters with the air. Filters of this type need to be dipped at regular intervals to remove the dirt and to keep the surfaces moist with oil. Units of this type are sometimes made up into a travelling belt form driven by a motor similar to water screens, which eliminates the bother of periodically cleaning the units.

Air Conditioning

Modern air conditioning systems have for their purpose the supplying of clean, healthful air, properly heated or cooled and humidified to give greatest

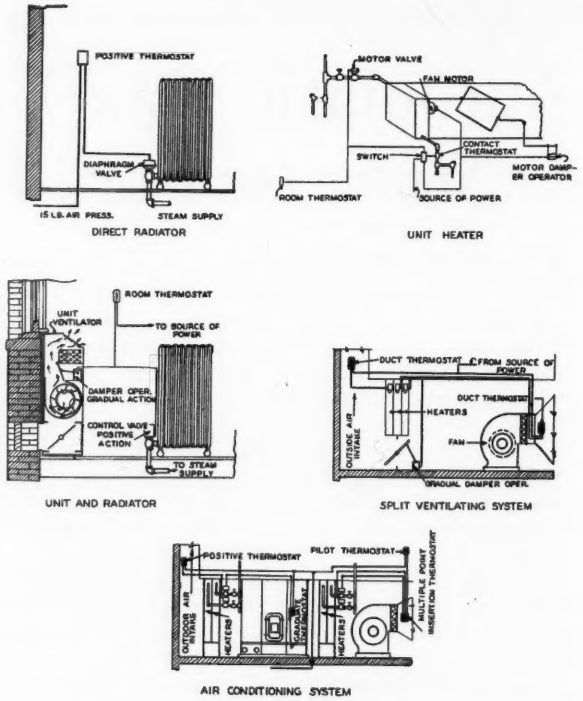


Fig. 6. Diagrams of several temperature control systems

comfort possible to the occupants of the room. The complete equipment used therefore must include means for removing all dust from the air to be delivered, either filters or air washers, usually the latter; coils for heating or cooling the air; means for maintaining the air at the desired humidity; fans for driving the air through the conditioning equipment and delivering it to the room; and, in some cases where air is recirculated, ozonators are used to remove objectionable odors. A common arrangement is illustrated in Fig. 3.

Air washers, as commonly designed, work on the same principle as rain drops in cleaning the air. Spray nozzles are mounted across the air passage in such a manner that the dust particles in the air come in contact with the water spray and are carried to a settling or filtering basin, the water being recirculated through the nozzles with only periodic renewals. In another

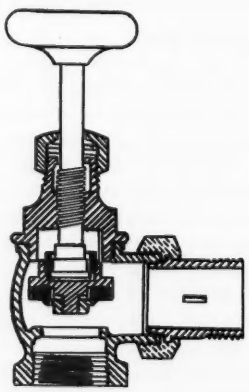


FIG.7

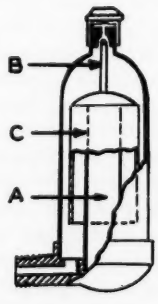


FIG. 8

Fig. 7. Common type radiator valve
Fig. 8. Radiator air valve of ordinary type

Table VII. Heat emission of hot water radiators

Values given in B.t.u. per square foot of hot water heating surface per hour, temperature difference 110 deg. i.e. water temperature 180 deg., room temperature 70 deg.

Type of Radiator	Height of Radiator			
	22 in.	26 in.	32 in.	38 in.
1 col.	193	188	185	183
2 col.	183	177	173	169
3 col.	172	167	162	156
4 col.	162	157	152	146
Window radiator		187		
Wall radiator (horizontal)		197		
Wall radiator (vertical)		193		
Pipe coils		202		

Table VIII. Elbow equivalents of fittings used in hot water heating systems

Fitting	Equivalent	Fitting	Equivalent
90 deg. elbow	1.0	Open gate valve	0.5
45 deg. elbow	0.7	Open globe valve	12.0
90 deg. long turn elbow	0.5	Angle radiator valve	2.0
Open return bend	1.0	Radiator	3.0
Tee	2.2	Heater	3.0

form, air is impinged against surfaces kept wet with water trickling over them.

Considerable variation exists in working conditions and people's clothing habits. These determine to a great extent the comfort zone of air temperature and humidity. Investigations, however, have been made and expressed in chart form, Fig. 4, by the American Society of Heating and Ventilating Engineers which can be used as a guide in establishing desirable conditions in any building.

It is customary to use the air washer to regulate the amount of moisture in the air delivered to the room. Air passed through the washer without change of temperature tends to become saturated at its entering wet-bulb temperature. Lower humidity may be secured by lowering the temperature in the washer, then heating the air to the desired temperature as it passes from the washer. The tempering coils in the intake heat the air to a temperature above the freezing point of the water in the washer.

Control Systems

Temperature control of rooms is effected by varying the amount of heat supplied. The approved method is by means of thermostats that control the opening and closing of radiator supply valves, valves supplying steam to air heating coils in indirect systems and the position of dampers in air ducts, or the steam or the electric current to unit heaters. The thermostats are usually placed at the breathing line, which is about 5 ft. from the floor, and near the coldest wall in the room.

Three general types of thermostats are in common use, as illustrated in Fig. 5, these consist of the diaphragm type, the direct expansion type and the bi-metallic type. The first two may act directly upon the valves or dampers although the movement of the direct expansion type is so limited that multiplying devices must be used so that the direct expansion type is usually, and the bi-metallic type always, used to control some actuating force such as compressed air or electricity, which in turn actuates the valve or damper mechanism controlling the heat supply. Several arrangements are shown in Fig. 6.

Valves used in heating systems should be of the gate type where in service they are either wide open or closed tight, valves for regulating purposes should be of the globe angle type, preferably, or the straight globe type, balanced types being used wherever they are controlled by automatic regulation.

Ordinary radiator valves are of the angle type provided with a union for connection with the radiator, see Fig. 7. Stems of these valves are packed with soft packing which is a common source of trouble and has led to the development of so-called packless valves in which packing is replaced by a grooved hard rubber washer which is held against the seat by a spring.

To remove air which accumulates in radiators when they are cold, some form of air valve is essential. A hand operated cock may be used but some form of automatic valve, that allows air to escape but closes as soon as hot steam reaches the valve, is much to be preferred. These valves are located on the end of the radiator opposite the supply connection. Cold radiators sometimes fill with condensate and to provide against leakage at the air valve, designs similar to Fig. 8 have met with success. The post A is of a composition that expands rapidly when heated to force the stem B against the seat and close the valve. If water accumulates, the inverted bucket, to which the stem B is attached, acts as a trip and closes the air valve.

Hot Water Heating Systems

In hot water heating systems temperatures are not as high as with steam so radiating surfaces must be considerably greater for the same heat requirements. Estimates are usually based on an average water temperature in the radiator of 180 deg. F. and a room

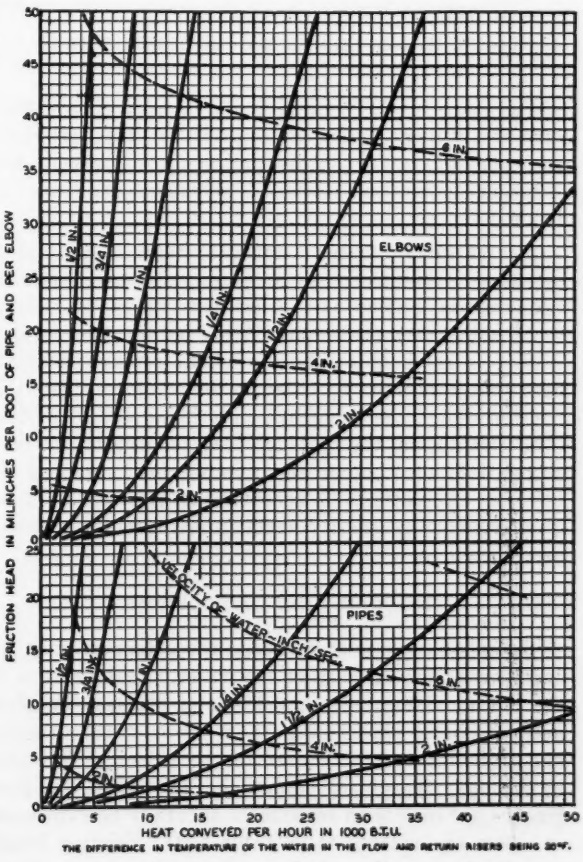


Fig. 9. Friction heads for hot water pipes and elbows

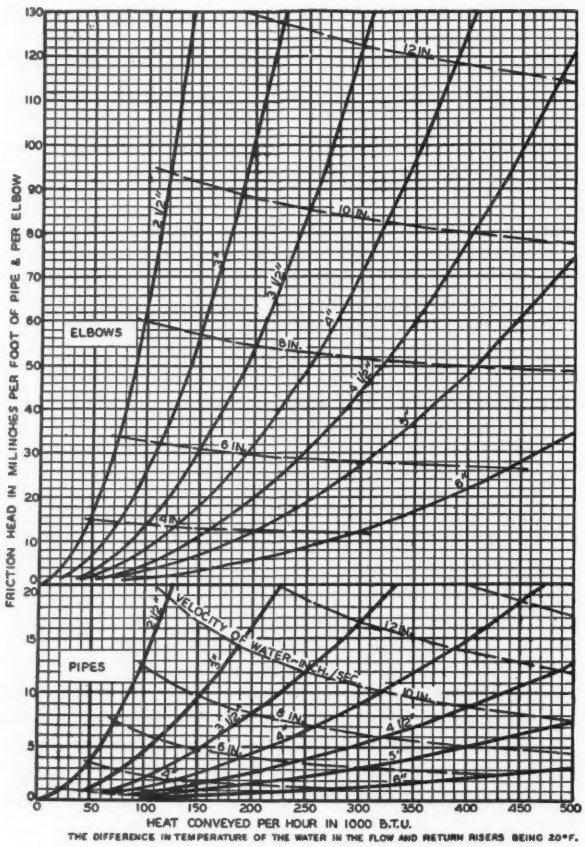

FRICTION HEAD IN MILINCHES PER FOOT OF PIPE & PER ELBOW
ELBOWS
PIPES
VELOCITY OF WATER-FEET PER SEC.
HEAT CONVEYED PER HOUR IN 1000 B.T.U.
THE DIFFERENCE IN TEMPERATURE OF THE WATER IN THE FLOW AND RETURN RISERS BEING 20°F.

Fig. 10. Friction heads for hot water pipes and elbows

temperature of 70 deg., giving a temperature difference of 110 deg. Under these conditions the heat radiated per square foot of heating surface per hour for different types and sizes of radiators is given in Table VII.

Water in hot water heating systems is circulated by either natural change in weight due to change in temperature, known as the gravity system, or it may be forced by means of a circulating pump. The gravity system is applicable where vertical piping predominates but care must be taken in the design to keep the friction down, the basic principle being that, for uniform circulation, the pressure head tending to produce circulation must equal the friction head tending to prevent circulation. Wherever the friction head is greater than the gravity head, forced circulation must be resorted to.

Friction Head Calculations

In calculating friction heads three factors must be considered: the velocity of the water, the diameters of the pipes and the types and kinds of fittings. Friction head in piping varies as the 1.78 power of the velocity and in fittings as the square of the velocity. Friction in fittings, therefore, cannot be expressed in pipe lengths but may with reasonable accuracy be expressed in elbow equivalents as in Table VIII. Friction heads in milinches per foot of pipe and per elbow for various pipe sizes and velocities and the heat conveyed per hour may be found by the use of the charts, Figs. 9 and 10, and from the chart, Fig. 11, the pressure heads in gravity systems can be determined.

To care for the expansion of the water in the system due to increase in temperature, the provision of an expansion tank is necessary. The connection to the heating system is from the highest point in the system to the bottom of the tank, located several feet above the circulating system, from the top of the tank a vapor pipe leads to the atmosphere and an overflow pipe carries any excess water to the sewer. The size of this tank is ordinarily based on the expansion of water from 50 deg. to 200 deg. which is estimated at 4 per cent increase in volume. Thus the tank should have a volume equal to 0.04 the water capacity of the hot water system it serves.

Acknowledgment

In gathering the data presented in this article many sources were referred to and information has been used freely from published works. To the authors and publishers of these books we take this method of acknowledging sources of information not otherwise given specifically in the article. The principal sources were: The American Society of Heating and Ventilating Engineers Guide; Heating and Ventilation, by Allen and Walker; Designing Heating and Ventilating Systems, by Charles A. Fuller; and Mechanical Equipment of Buildings, Vol I Heating and Ventilation, by Harding and Willard.

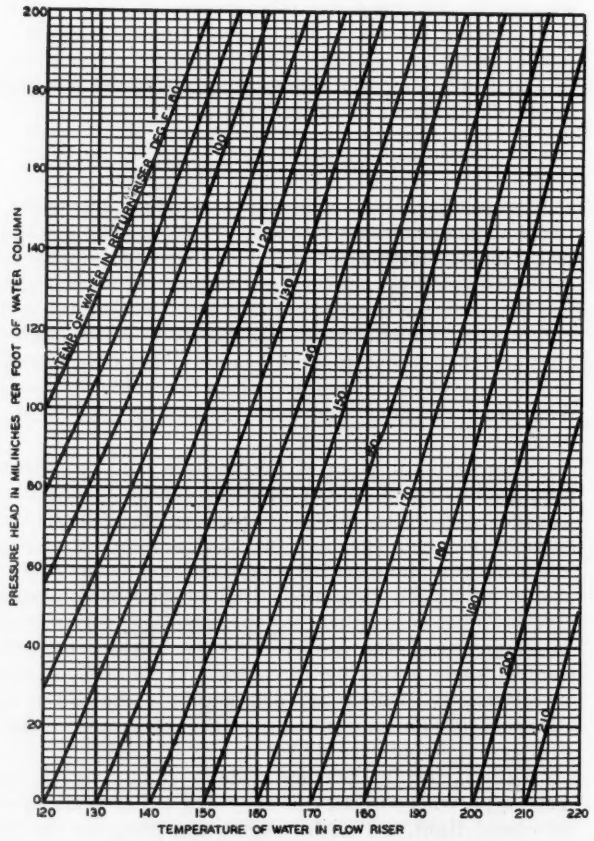

PRESSURE HEAD IN MILINCHES PER FOOT OF WATER COLUMN
TEMP. OF WATER IN RETURN RISER 180°-190°-200°
TEMPERATURE OF WATER IN FLOW RISER

Fig. 11. Pressure heads in hot-water systems

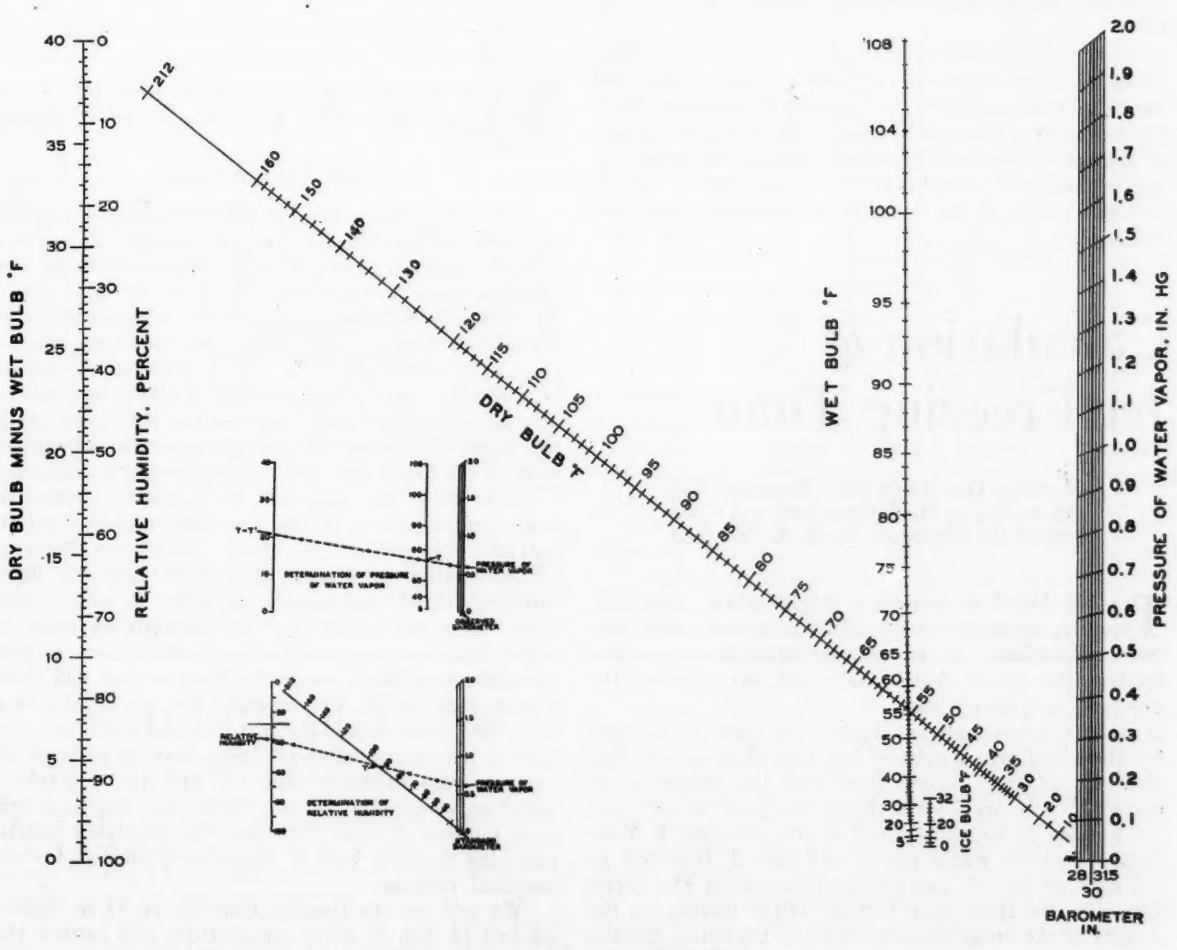
Psychrometric Calculations *by* Chart

Donald B. Brooks of the Bureau of Standards Constructs Accurate Chart to Shorten Calculations

BASED ON the psychrometric formula and developed primarily for use in the determination of the pressure of water vapor from psychrometric observations it was found that the addition of two scales to the accompanying chart permitted the accurate evaluation of relative humidity as well. In comparison with the customary double interpolation tables it has been found that the use of these charts increased the precision and halved the time required.

To use the chart, place a straightedge so that it intersects the extreme left scale at the value of the difference between wet and dry-bulb temperatures and intersects the wet-bulb scale at the value of the wet-bulb temperature. Extend this line to the right to its intersection with the vertical line which represents the barometric pressure and read the pressure of water vapor on the scale at the extreme right. This value includes all necessary corrections.

To determine the relative humidity, transfer the value of the pressure of water vapor obtained as described to the corresponding point on the central heavy vertical line representing standard barometric pressure of 30 in. Connect by straightedge this point and the point representing the dry-bulb temperature on


DRY BULB MINUS WET BULB °F
RELATIVE HUMIDITY, PERCENT
DRY BULB °F
WET BULB °F
ICE BULB °F
PRESSURE OF WATER VAPOR, IN. HG
BAROMETER IN.
DETERMINATION OF PRESSURE OF WATER VAPOR
DETERMINATION OF RELATIVE HUMIDITY

Relative Humidity Is Easily Obtained From the Wet and Dry Bulb Readings

the diagonal line marked "Dry Bulb". Extend the line to its intersection with the vertical line on the left and read relative humidity on the inner left scale.

Example

Suppose a psychrometer reads 95 deg. F. on the dry bulb and 70 deg. F. on the wet bulb when the barometer is 30.5 in. Hg. To find the pressure of water vapor, place a ruler so that it intersects the "dry bulb minus wet bulb," scale at 95 — 70 = 25. Adjust so that it meets the "wet bulb" scale at 70, and note the point at which it intersects the 30.5 in. barometer line (first line right of heavy vertical line marked 30); the value of the humidity so obtained is 0.46 in. Hg.

Continuing the example started above, locate the point on the heavy vertical 30 in. barometer line which represents 0.46 in. Hg. pressure of water vapor, and connect this point with the point at 95 deg. F., near the middle of the diagonal line marked "dry bulb," By extending this line to its intersection with the vertical line at the left, the value 27 per cent relative humidity is obtained on the "Relative Humidity, per cent" scale on the inner side of the left vertical line. Note that this scale reads from 0 at the top to 100 at the bottom.

Formula

In obtaining the pressure of water vapor when the wet-bulb temperature is below freezing, the scale marked "Wet Bulb" is employed if the psychrometer was used with either supercooled water or a frozen wick. However, more accurate results can be obtained with an ice-coated thermometer, and the "Ice Bulb" scale (to the right of the "Wet Bulb" scale) is used in place of the "Wet Bulb" scale.

The chart is based on Professor Ferrel's psychrometric formula, which is used in the United States Weather Bureau's Psychrometric Tables. The formula is

$$e = e' - 0.000367P\ (t - t')\ [1 + (t' - 32) \div 1571]$$

in which t and t' are the temperatures of the dry and wet-bulb thermometers, in degrees Fahrenheit; P is the barometric pressure at the psychrometer, in inches of mercury; e' is the saturation pressure of water vapor in inches of mercury at the temperature t' of the wet bulb; and e is the atmospheric humidity in inches of mercury.

Calculation *of* Ice Freezing Time

Working Out a Few Easy Formulas Will Put an End to Much Guesswork and Criticism of the Operator. By H. A. Cranford

TO BE ABLE to handle a refrigeration plant efficiently, the engineer should know how to make certain calculations. It is not my intention to go into mathematics deeply, but I shall work out a few of the problems in a simple way.

I have asked many engineers how long it required for them to freeze a cake of ice. Almost to a man they answer, "48 hr." Almost invariably this answer is incorrect. There are several things that tend to influence the number of hours required to freeze water: 1, Temperature of the water put in the can; 2, thickness of the cake of ice; 3, average temperature of the brine. These are the three main factors. Other factors are the density of the brine, the circulation of the brine, and the quantity and temperature of the water used to fill the cores. All of these and perhaps others of lesser importance enter into an exact calculation of the actual time required to freeze a can of water into a cake of ice. It resolves itself into a problem of how many British thermal units the can of water contains, and the rate at which the ammonia will absorb those units through the brine as a transfer agent.

Freezing Time

But there is a simple formula that any engineer who can add, multiply, subtract and divide, may calculate closely enough for all practical purposes, the time required to freeze the water.

Ice cans have been standardized until most plants produce a cake of ice that averages 11 in. thick. Also, a rather large percentage of the plants have their capacities based on 14 deg. F. temperature. We know the freezing point of water to be 32 deg. F., or rather we accept 32 deg. for practical purposes. The following formula will come close enough for the average engineer. Freezing time in hours equals 7 times the square of thickness of the cake in inches divided by freezing point of water minus brine temperature. The figure 7 in the above is simply a factor that has been found correct in this calculation. Now we will take the above cake of ice, 11 in. thick with brine temperature of 14 deg. F. Using the formula

$$\frac{7 \times 11 \times 11}{32 - 14} = \frac{847}{18} = 47 \text{ hr.}$$

That is 47 hr. are required to freeze water into a cake of ice 11 in. thick with a brine temperature averaging 14 deg. F.

Brine Temperatures

Now all engineers are not careful enough when reading brine temperatures, or keeping records. To get even a fairly accurate record of brine temperatures the temperature must be read correctly every 30 min. Under no conditions at longer intervals than an hour. Harvesting as well as many other things may run temperatures up causing wide variations, and if temperatures are not read often it may so happen that readings and records may be taken and made right at the low point of the thermometer, causing the average temperature to appear to be much lower than the actual average temperature.

It is often the case that the engineer carries his brine temperature at 14 deg. but simply cannot get the tonnage capacity of the plant. Some manufacturers of ice making machinery have been known to figure things as closely as possible, in order to meet competition, with the result that the capacity is rated, or rather based on theoretical calculations; under the ideal operating conditions, while the plant is new and clean, it may come up to the capacity for which they were sold. But when things begin to foul up a bit, and they have a pernicious habit of doing that in spite of the engineer, the capacity falls off, and the engineer is called on to explain things. There may not be a sufficient number of cans. This may be calculated and the following formula will be found close enough for any practical purpose.

We will use the freezing time for an 11 in. cake of ice and 14 deg. F. brine temperature and assume that the cake of ice weighs 300 lb. Multiply the weight of

the cake (300) by the number of hours in a day (24) and divide the result by 2000 lb. (1t.). Divide the freezing time we found in the first formula (47 hr.) by result obtained in last formula.

$$\text{Thus } \frac{300 \times 24}{2000} = 3.6 \quad \frac{47}{3.6} = 13+$$

The plant to produce capacity at 14 deg. F. average brine temperature with the cakes weighing 300 lb. and averaging 11 in. thick, must be provided with 13 plus or rather 14 cans for each ton of ice expected. If there aren't this many cans allowed per ton of rated capacity the plant simply will not come up to capacity unless the brine temperature is lowered. If the brine cooler or coils, compressor, or high side have been calculated on the same basis that the number of cans were calculated, this may be impossible, or if possible, may be done at such an increased expense that it is not desirable.

Operating Instruments

In order to make a check-up on an ice plant and make it right, a recording thermometer is necessary. No engineer should be willing to try to operate a plant without one. It is the only way he can know what goes on when he is not present. I have known more than one engineer who saved himself by having a proved record of what the temperatures are when he was away and his assistant in charge.

Another thing that has caused the chief much worry when his plant fails to come up to rated capacity is this: A lot of manufacturers require him to make cakes from 10 to 50 lb. overnight. In the calculation above you notice that we use 300 lb. as the weight of the cake. Now if you will substitute 325 and make the calculation you will see that the result is changed, which proves that the thickness of the cake determines its freezing time and length does not.

This is why many plant managers will argue that the extra 25 lb. does not have any effect on capacity.

But you never get anything for nothing. If you are filling cans to 325 lb. but being credited with only 300 lb., the compressor, low side and high side are being called on to remove those additional units of heat.

If they are not designed to do it then you can not maintain the 14 deg. F. average temperature. If they will do it, while you may produce the rated capacity plus this overweight, for which you get no credit, you are surely paying for it in power which increases your power cost per ton.

Plant balance is what determines the efficiency of any plant and every engineer should be able to make simple calculations to check his plant close enough to be able to prove what he is doing.

Bending of Belts

By W. F. Schaphorst

ASK THIS question of any belt user, "Which belt is bent more, the belt shown in Fig. 1, or the belt shown in Fig. 2?" Ninety-nine times in a hundred you will be given an incorrect answer.

There is no question but that the vast majority of belt users believe that a belt only slightly deflected by the wrapper pulley, as in Fig. 1, is bent or flexed less than the belt in Fig. 2 which is deflected the maximum amount. That belief is erroneous. There is no difference whatever in the amount of flexure so long as the diameter of the wrapper pulley is the same in both instances. If the deflection in Fig. 1 is only one inch, while the deflection in Fig. 2 is ten times more, the amount of belt bending is exactly the same in both instances.

A belt bends *only at the points of tangency.* Give this matter a moment's thought and any reader will see that the amount of bending at the point of tangency is identical in both examples. Each wrapper pulley has

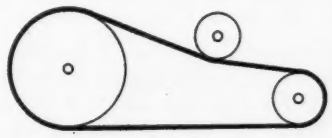


FIG. 1

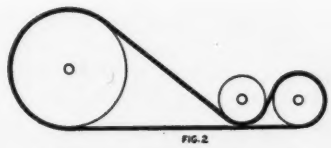


FIG. 2

Two cases of belt bending by idlers.

only two points of tangency and no more. Therefore the total amount of bending in the belt while passing onto and off of either wrapper pulley is identical. The same thing is true as regards the driving and driven pulleys. The belt on Fig. 2 receives no more punishment, due to bending, than the belt on Fig. 1. For pulling the load, and from all other standpoints, Fig. 2 is preferable. The belt, Fig. 1, will have to be wider to have the same capacity as the belt in Fig. 2.

In view of what I have shown above, it is now evident that the "rapidity of flexure" of a belt is of no importance so long as the belt is sufficiently flexible to bend the necessary amount. But I would like to point out the fact that flexure is *more rapid* on the wrapper pulley of Fig. 1 than on Fig. 2 because the points of tangency are closer together. The points of tangency are closer together on *all* of the pulleys in Fig. 1. If the belt is inclined to heat, due to bending, it is plain that the number of bends per minute and the amount of bending per minute are the factors that count. Obviously the belt in Fig. 2 is longer than the belt on Fig. 1, therefore there are fewer bends per minute on Fig. 2 and the amount of bending per minute is correspondingly less.

Further, the belt on Fig. 2 will remain cooler than the belt on Fig. 1 because it need not be kept so tight; it will slip less and it will have greater pulling capacity.

Drives of this type give no trouble when they are correctly designed. Sometimes we find insufficient flywheel weight, yet the belt is blamed for the trouble. If the flywheel is too light, the belt will be subject to severe jerks and fluctuations, especially on drives of variable load. The lighter the flywheel the more severe the fluctuations.

Readers' Conference

A Handy Coil Winding Machine

To FACILITATE the winding of coils for various purposes around our utility company shop I recently built the coil winding machine shown in the accompanying illustrations. It has been found so handy and is so simple to build that I thought other readers might build one like it.

Little equipment is needed. A fractional horsepower motor (I used an old phonograph motor) together with one 90 to 1 worm gear and one 20 to 1 worm and worm wheel are about the only equipment needed that the reader cannot readily make himself.

At the right is shown a top view showing the location of the motor together with the coil holder and wire tension drum.

As will be seen from the photograph the motor shaft carries the worm which meshes with the (20 to 1) worm wheel. This combination transmits the power to a pointed shaft. The purpose of the point is, of course, to furnish a means of holding small relay cores whose ends have center holes. The other support for the core being wound is another pointed shaft held in a movable bearing. This bearing can be shifted to or away from the stationary point, allowing the accommodation of long or short windings. A slotted sector set in the wood base, together with a carriage bolt with wing nut, hold this movable bearing in the correct position.

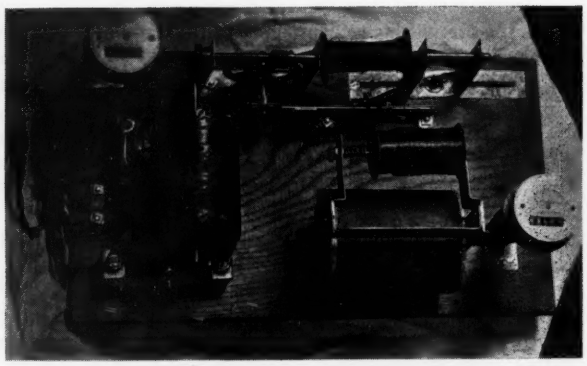
On the stationary pointed shaft is mounted the other worm meshing with the (90 to 1) worm wheel which drives the "heart" cam. This cam may be taken off an old sewing machine or may be made out of No. 12 gage sheet metal using one off a sewing machine for a pattern. A slotted lever with a metal finger (held constantly in contact with the cam by means of a spring) moves back and forth when the cam revolves giving the desired motion for guiding the wire.

The actual wire guide consists of a hinged vertical member with a hole or "V" for the wire to ride. Holes in the horizontal reciprocating member and a slot in the vertical member allow for adjustment of the degree of swing. The hinge at the bottom of the vertical member (wire guide) may be centered on the winding by means of another slotted member fastened to the wood base.

A drum constructed from sheet metal and having a circumference of one foot keeps track of the length of wire. A section of old inner tube slipped onto the drum prevents the wire from slipping as it passes around the drum. An old water, gas or electric meter register does the counting and is connected by means

TWO VIEWS OF THE HOME MADE COIL WINDING MACHINE

At the left is shown a side view showing the construction of the wire guiding mechanism.



of a flexible shaft made by winding a tapered spiral spring. A similar counter is connected to the stationary pointed shaft to keep track of the turns on the coil.

A snap switch must be installed to control the motor since snarls and tangles are often made worse by failure to stop the machine quickly. Although the writer has gotten along without it, a means of reversing the motor would also come in handy.

All of the metal bearings and other members were made from No. 12 gage sheet metal and have done very nicely. The automatic wire guide works well on scatter windings or for general winding from one spool to another. Naturally, it cannot lay on a perfect layer for all of the many wire sizes that will be used. For this type of work much better results will be obtained if the wire is guided by hand. Since a great many of the smaller coils and relays (such as can be handled by the machine) are scatter wound the automatic guide will earn its keep on many occasions.

This machine has one regular job of rewinding relays (A T & T No. 87E) used in connection with the company's high line telephone. These relays persist

in burning out during lightning storms. Usually the winding is intact except a few turns near the core which have shorted to ground. (Core grounded.) It is a simple matter to run the wire off and on again with the machine to say nothing of the money saved in not having to purchase new relays.

Sparta, Wisconsin. VERNON W. PALEN.

Loose Pulley Lubrication

IT IS HARD to think of any device that is more difficult to oil satisfactorily than the loose pulley. Any oil that is introduced into a loose pulley must be either run through the hub of the pulley itself, or through a center hole in the shaft upon which it runs. Getting oil through the shaft, and out through weep-holes to form an oil film between shaft and pulley, is a complicated process in most cases, since when the machine is running the shaft itself revolves. Such a process is therefore not very practical, and is but seldom used.

Relative length of life greater than could otherwise be obtained results from bushing the pulley with bronze, and this has been a method highly favored, but even where bronze is run to steel, the lack of oil will soon start it to cutting, and without question it is lack of oil that causes the great bulk of loose pulley trouble. And what plant has not had such troubles.

Since, where oil is to be gotten to the average loose pulley bearing, it must be introduced through the hub, and since centrifugal force of the running pulley tends to throw the oil outwardly, importance attaches to the type of oil channel that is used. A simple open hole is worse than none, for the oil is thrown out of the pulley completely, and in addition finds its way onto the belt, soon causing both belt and pulley trouble. A threaded plug fitted into a threaded oil hole serves to hold the oil in the pulley—in some cases it is placed in the pulley hub, but a better idea is an oil hole drilled right through the pulley face and down through a spoke into the bearing.

Excellent results, where a plain bearing surface is used, have been obtained by inserting a pulley bushing fitted with an oil reservoir, which will receive a considerable amount of oil at a time, making it unnecessary to oil the pulley more than once a week. Some pulley bushings have been channeled out with a circumferential channel on the inside, and a ring of felt inserted to help hold the oil. In one special pulley that has come to my attention, the bushing is made exceptionally large, and reservoirs are sunken into its outer surface, so that the oil is stored between bush and pulley, instead of between the bushing and the shaft. In order to allow oil to enter between the pulley bushing and the shaft, a large number of small weep-holes are provided, leading from the reservoirs through the bushing. Thus, oil finds its way through in sufficient amounts whenever the pulley comes to rest, and through lamp wicking in two channels provided for it, to the surface of the shaft. Such pulleys cause little trouble.

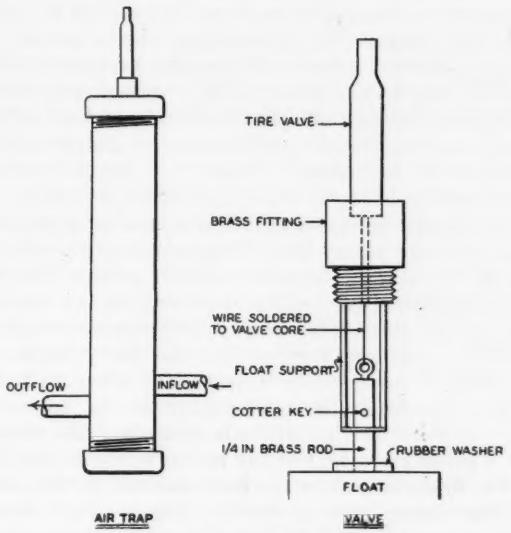
Without a doubt, however, ball bearings lend themselves best for loose pulley service, because ball bearings require such a small amount of lubrication to keep them functioning properly. Ball bearings have been successfully applied to loose pulleys, and there are some who specialize in their manufacture. Consequently they are becoming quite popular of late years.

Peoria, Ill. JOHN E. HYLER.

Home-Made Trap to Remove Excess Air from Water Pipes

A CERTAIN DWELLING house was recently confronted with the problem of an excessive amount of air getting into the water pipes. The water was pumped into the house from a well 160 ft. deep. There were two check valves in the piping system—one between the pump and the house and the other near the bottom of the well. The first valve functioned properly, but the second developed a small leak. When the pump was idle the water in the well pipe slowly ran out, causing air to be drawn into the pipe through the pump packing. When the pump started, this air was carried through the pipes into the house. Expanding in the faucets from a 40-lb. pressure, this entrained air usually sprayed water all over the room.

Instead of removing the pump and repairing the check valve, the problem was solved by installing the home-made air trap shown in the diagram. A piece of 3-in. pipe, 18 in. long and capped at both ends, was used as the air chamber. Two ¾-in. nipples, threaded and brazed into opposite sides of this pipe, provided the means of connecting the trap into the water main. A



Details of trap construction

hole was drilled through the center of one of the 3-in. caps and this hole was threaded with a ¾-in. tap. A piece of 1-in. brass rod 2 in. long was turned down and threaded to screw into this hole. A ⅛-in. hole was drilled lengthwise through the brass fitting and, at one end, the hole was enlarged to about ⅜ in. An automobile tire valve was soldered into this enlarged hole and a piece of rust-proof wire was soldered to the lower end of the valve core. This wire was attached to a float which consisted of a tightly corked bottle enclosed in a wire cage with the neck down. This float was heavy enough to open the valve if the chamber got full of air.

The valve mechanism was designed so that a new

valve core could be inserted without removing one of the 3-in. caps. Two small brass rods were soldered into the brass fitting to form a float support as shown in the diagram. A brass washer soldered to the lower ends of these rods prevented the float from dropping down into the chamber in case the valve wire broke. This arrangement also kept the float from rising too high. A new valve core could be inserted by simply unscrewing the brass fitting and raising the whole valve mechanism high enough to attach the wire to the float.

This air trap has been in service several months and has removed all the entrained air without giving any trouble.

Chapel Hill, N. C. E. W. WINKLER.

Adiabatic and Isothermal Compression

AROUND A POWER PLANT compression and expansion play an important part, as the steam engine, steam turbine, air compressor and refrigeration compressor, each of which makes use of one or both, are integral parts of the plant. These machines must be installed, operated, kept in repair and run at the highest possible efficiency. This latter means knowing something about the theory upon which they are designed.

Two common terms heard, especially in connection with compressors, are adiabatic and isothermal compression. They are both terms heard frequently in connection with efficiency guarantees when buying a compressor as manufacturers are not in full accord as to which basis should be used for calculating this important figure. Actually it does not make any difference as long as you know which was used and what it means. Adiabatic efficiency is higher and as it more nearly approaches the performance of the actual machine while isothermal efficiency is based upon the performance of a theoretically perfect machine.

Everyone knows that when a gas is compressed heat is generated so that if compression were carried out in an insulated cylinder so that none of the heat of compression were radiated off or lost the temperature would rise. This rise in temperature would expand the gas and further increase the pressure. If the heat of compression were carried away as fast as it was generated the temperature of the gas would not rise above the initial temperature and the pressure for a given movement of the piston would be less than in the first case where the heat was not carried away.

The easiest way to explain it in a simple manner is by means of an indicator card which is familiar to all engineers and which shows up the difference in a clear, simple and convincing manner. Starting at the beginning of the compression stroke, 1, and remembering that none of the heat of compression is removed during adiabatic compression, the compression line would move up along the line 1-2. If now the piston were stopped and the gas or air cooled to the initial temperature the volume of the gas would shrink as it was cooled and as the volume of the cylinder remains constant the pressure would decrease along the line 2-3. To reach the desired pressure of say 100 lb. gage again the piston would have to be moved forward and the air would be compressed along the line 3-4.

If the heat of compression were removed as fast as it was generated so that the initial temperature was never exceeded the compression line would be along 1-5, Fig. 1, which is an isothermal compression line as isothermal means at constant temperature. It is plain to be seen that the saving in power of isothermal over adiabatic compression would be the area 1251 which is a considerable portion of the work area of the card. As in an engine indicator card the area of the card is a measure of the work necessary for compression.

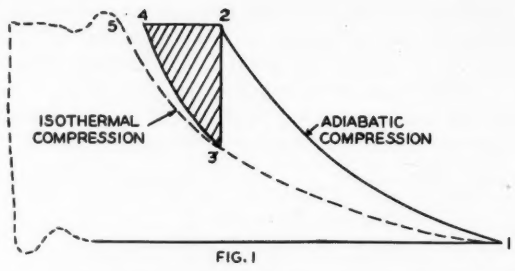


FIG. 1

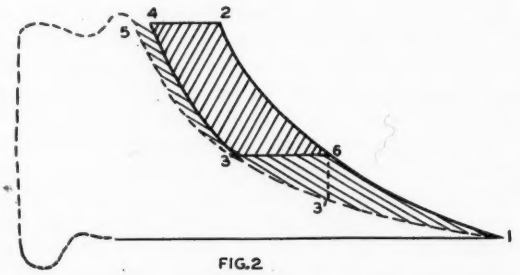


FIG. 2

Fig. 1. Isothermal compression requires less power than adiabatic.
Fig. 2. Two stage compression saves the power area 6243.

Now it is obvious that a compressor should be designed for adiabatic compression but unfortunately such a compressor has not yet been invented let alone built. Some of the early ones had a water spray in the cylinder. This was known as wet compression but is no longer used very often. The modern machines have the cylinders water jacketed and closed coolers between cylinders. The reason for the coolers, usually called intercoolers because they are between the cylinders, can be shown on the indicator card. For instance, if starting at 1, Fig. 2, again the piston was moved to 6 and stopped and the gas cooled to the initial temperature it would shrink to point 3 and further movement of the piston would cause compression along the line 3-4.

Saving in power over adiabatic compression would be the area 6243 while the increased power over isothermal power would be the sum of the areas of the two triangles 163 and 345. The reason for cooling the gas this time at constant pressure along the line 6-3 instead of at constant volume along 6-3′ is that in an actual compressor the intercooler is located between the cylinders and operates at practically constant pressure. It is also evident that if an isothermal compressor could be built that there would be no need for using a number of stages for high pressures.

For isothermal compression the line 1-5 can be calculated from the formula

$$P \times V \text{ equals a constant}$$

for adiabatic compression

$$P \times V^{1.41} \text{ equals a constant}$$

In these P is the absolute pressure, that is gage pres-

sure plus 14.7 lb., and V is the Volume in any units desired, usually cubic feet. The exponent 1.41 is the theoretical value, in an actual compressor with water jackets and intercooler the exponent is about 1.3. These and the formula

$$P \times V \text{ equals } 0.37 \times T$$

gives all the formulas necessary for calculation any problem for compressed air. In this last one T is the absolute temperature which is the temperature F. plus 460. The pressure is used as pounds per square inch gage and the formula is for one pound of air and the constant 0.37 is the regular air constant 53.3 divided by 144, so as to use pounds per square inch instead of pounds per square foot.

Springfield, O. F. PAUL.

Air Preheaters

Q. We have two 361-hp. Riley natural draft boilers which operate at times up to 200 per cent rating. These boilers are equipped with steam atomized oil burners, steam flow meters, feedwater meters and CO_2 recorders. We burn up to 5600 gal. of 18,200 B.t.u. (8.13 lb. per gal.) oil per 24 hr. Temperature of oil to burners runs around 220 deg. F. Stack temperatures 500 to 600 deg. F., and the efficiency 80 to 85 per cent.

What saving can we show by installing an air preheater in the uptake? What would be the approximate cost of such a heater?

A. Information and data given are not sufficient to intelligently prepare such a study so we have made a number of assumptions. Our calculations are based on the following data:

1. Two 361-hp. boilers, operating at 150 per cent average rating.
2. 36,300,000 B.t.u. per hr. delivered with steam in both boilers above feedwater temperature.
3. Average flue gas temperature 520 deg. F.
4. Average CO_2 in flue gases, 12.5 per cent (25 per cent excess air).
5. Average efficiency of boiler, 80.5 per cent.
6. Plant operates 24 hr. per da., 350 da. per yr.
7. Heat content of fuel oil 18,200 B.t.u. per lb.
8. 340 lb. per bbl.
9. Fuel cost, $1.50 per bbl.

Since oil is the fuel, the exit gas temperatures from the air heater should be kept well above the dew point to prevent condensation of the sulphurous gases contained in the flue gases. Such condensation would cause scale formation in the air heater tubes and possibly corrosion. For our calculations, we have therefore assumed that it is desired to reduce the exit gas temperature to 335 deg. F. corresponding with 520 deg. F. temperature of the gases entering the air heater.

The air heater surface required to reduce the flue gas temperature from 520 to 335 deg. F. is 2900 sq. ft. It is assumed that a total of 90 per cent of all the air required for combustion will flow through the air heater. The air temperature will rise from an entrance temperature of 70 deg. F. to a discharge temperature of 305 deg. F. Based on these air and gas temperatures, the overall efficiency of the two boilers will then be 85 per cent, so that the rise in efficiency of the boiler installation with the air heater in service is 4.5 per cent.

Oil burned when a total of 1083 b.h.p. is being generated at an efficiency of 80.5 per cent is 2475 lb. per hr. With an efficiency of 85 per cent the fuel oil burned is 2348 lb. per hr. This gives a saving of 5.1 per cent of the oil used without airheater operation. The yearly oil bill for the boiler plant without the air heater for 24 hr. per da., 350 da. per yr. is $91,800 and with operation of the air heater the yearly oil bill will be $87,150, giving a yearly saving in the fuel bill of $4,650.

Against this saving, the following must be considered:

Approximate cost of 2900 sq. ft. air heater, erected.	$3,500
Approximate cost of forced and induced draft fans and motors	1,500
Approximate cost of hot air duct and structural steel changes	500
Total investment	$5,500

Consumption of electrical power to drive forced and induced draft fans may be approximately 25 kw-hr. and, assuming that electric power is being purchased in this plant at one cent per kw-hr., the yearly power bill for driving forced and induced draft fans would be $2,100.

Interest and depreciation charges on the investment of $5,500 at 10 per cent would be $550 per yr., giving a net saving of $4,650—($2,100 + $550.00) = $2,000 per yr. The actual returns from the air heater installation would be approximately 37 per cent per year on the basis of the investment.

Assumptions have been made on the basis that only one air heater is used for both boiler units, that is, that the exit gases from both boilers would pass through a single air heater. Since only one induced draft fan is contemplated, it would be advisable to provide for a gas by-pass of the airheater so that the boilers can be operated by natural draft if cleaning of the air heater or repairs to fans and motor are found necessary.

The question places the airheater in the uptake, apparently having in mind natural draft operation and elimination of the induced draft fan. It is very difficult to prepare a satisfactory installation of a natural draft air heater, especially where fuel oil is fired. In order to keep the draft loss through the airheater sufficiently low for operation with a natural draft stack, the velocity of the gases through the airheater would have to be kept so low that the rate of heat transfer would be very small, the air heater would become quite large and it would be exceedingly difficult to keep the surface clean since the scrubbing action of the gases passing through air heater tubes at high velocities would be lost.

Answered by M. H. Kuhner, Chief Mechanical Engineer, Boiler Division, Riley Stoker Corp., Worcester, Mass.

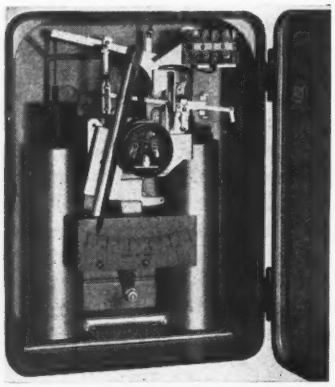
SAVINGS possible by the use of stokers are indicated by data from one manufacturer, gathered from the records of 160 owners. Average reduction in fuel cost 51 per cent; average annual return on investment in stoker equipment 49 per cent. The range of saving in fuel cost was from 39 per cent for replacement of hand firing to 68 per cent for replacement of oil burning, and range for return on investment about the same.

New Equipment

Control Trip Prevents Explosions

TO GUARD against explosive mixtures of fuel and air when lighting off pulverized coal, gas or oil fired boilers, Bailey Meter Co., Cleveland, Ohio, has developed a control trip which withholds fuel feed until the boiler is thoroughly purged.

The mechanism consists essentially of two oil sealed bells suspended from a beam to measure air flow through the boiler. A draft connection from the right-hand bell to the boiler furnace, and a similar connection from the left-hand bell to the last pass provides for the use of draft loss through the boiler as a measurement of air flow. The entire mechanism, including oil-sealed bells, snap-acting contactor and indicating pointer, is enclosed in a dust and moisture-proof pressed steel casing of attractive design.

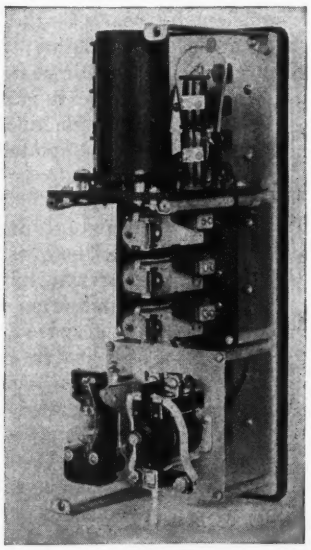


Although this control device is provided with an indicating pointer for calibration and checking, its primary function is to operate the snap-acting contactor shown in the circular casing between the two oil-sealed bells. This contactor is connected to the air flow mechanism by linkage in such a manner that it is necessary to run the rate of air flow through the boiler up to approximately 60 per cent of capacity before the contactor closes and permits operation of the fuel feeder motor relay or control valve. Once this contactor goes to the closed position it remains there until the air flow value approaches zero, thereby permitting operation of the unit throughout its entire control range without tripping out the fuel feed.

New G-E Automatic Synchronizing Relay

A NEW SYNCHRONIZING relay, featuring automatic compensation for errors due to source voltage difference and control-voltage variations, is now being manufactured by the General Electric Company for use as a part of the automatic switching equipment built by the G-E Switchgear Division, Philadelphia, Pa.

The relay is accurate, reliable, positive, and quick-acting. Its essential element is an advance transformer. This operates through a pair of thermionic tubes to control auxiliary relays so that the breaker closure is initiated with the proper advance time, according to the operating time of the breaker, to effect closing of the breaker near the exact instant of true synchronism (zero phase displacement).



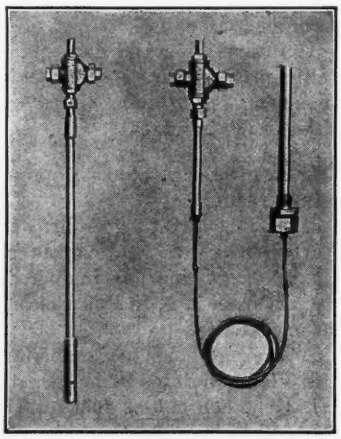
The relay, which may be used for either machine synchronizing or line synchronizing, in either automatic or manual stations, is compact and is simple in construction. All tubes and the few moving parts are mounted in a 5½ by 16 in. universal case with an auxiliary box 9½ by 17 in. mounted on the relay studs behind the panel. Connections from the relay to the auxiliary box are made through a cable having individual wires cut and adjusted at the factory to reach the correct studs.

Advantages of the new relay include the following: freedom from material errors due to voltage differences; quick and accurate synchronizing, even if the frequency variations are erratic; constancy of advanced time, even for varying frequency differences; reliability of performance; low energy consumption; compact arrangement.

New Sarco Temperature Regulators

TWO NEW INSTRUMENTS illustrated, have recently been added to the line of Sarco self-operated temperature regulators by Sarco Co., New York City.

Type KR-15 (left) is intended for the control of brine cooling coils as used for refrigeration and cold storage. In this model, the temperature-sensitive bulb is rigidly attached to the valve. The customary flexible connecting tubing is omitted. A compact and inexpensive unit is the result. As the valve is packless, no stuffing box is used. Frosting in service, therefore, cannot cause sticking of the valve. A key is furnished to enable the user to change the temperature at which the valve will hold the refrigerated space.



Type TR-20 (right). This is a new junior model of the Sarco tank regulator. It is made in three sizes, ⅜, ½ and ¾ in. It has a small bulb, fitted with union connection and is furnished with a short length of flexible connecting tubing.

This regulator was designed to make possible the use of automatic

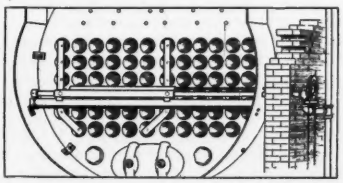
temperature control on equipment for which the standard regulator was too costly.

Vapor Spray Cleaning

FOR HIGH-PRESSURE vapor spray cleaning of machinery, skylights and walls, a new device provides heat, water pressure or friction and cleaning compounds by a vapor spray emerging at high velocity from a nozzle, all power being taken from an electric light socket. A solution tank, with automatic float level valve, proportion of compound and moisture controlled by the operator and nozzle control on the spray gun, rotary pump driven by electric motor are elements of the outfit. Steam is taken from the plant system. Pressure range is 50 to 250 lb. per sq. in. This model has been given the name Fireless Hypressure Jenny by the makers, Homestead Valve Mfg. Co., Coraopolis, Pa.

Diamond Straight-Line Blower

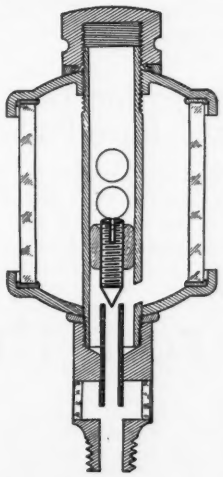
BY MOVING the two sets of nozzles across either the front or back tube sheet of the boiler, this new design of Straight-Line soot blower developed by Diamond Power Specialty Corp., Detroit, Mich., directs jets of steam straight through the boiler tubes. The operation is accomplished by opening the steam valve and rotating the chain wheel attached to the screw that moves the elements across the face of the tube sheet. The construction is simple and rugged with a minimum of moving parts and solid pipe steam connection.



ENGINEERS of The B. F. Goodrich Co. have developed a conveyor belt to be known as the Golden Ply Hot Material Belt, so constructed as to offer great resistance to abrasion even after prolonged exposure to heat. Contrary to usual results, the new belt actually registers a 31 per cent increase in flexing life after aging.

Improved Victor Lubricator

VICTOR automatic-force-feed lubricators, manufactured by the Victor Lubricator Co., Chicago, Ill., have recently undergone important improvements. Cadmium plated steel replaces brass for greater tensile strength and to reduce breakage loss. A new sight feed provides double visibility—reservoir supply as well as rate of feed. A new, larger filler tube permits easier, faster filling. A new top stamping, drawn and threaded, eliminates the hex nut formerly required. A new cap, redesigned to include a patented washer retainer, eliminates the cap retaining wire previously used, and a new valve control inside the filler tube, discourages tampering with the initial adjustment.



These lubricators are of air-tight construction, are completely self-contained, and feed oil under pressure generated within the lubricator (not by gravity) as dictated by the bearing's actual needs. Oil temperature variances, by causing expansion or contraction of the fractional cubic inch of air imprisoned near the base of the filler tube, regulate the rate of oil flow.

Carbondale Alternator System

CARBONDALE MACHINE CO., Carbondale, Pa., announces a new patented system of air agitation and water circulation for ice making. This system has been named the C-A System—an abbreviation for Carbondale Alternator System. Alternating air flow is used. For a predetermined period of time air flows to the cans in one-half of the tank. For an equal period of time air flow to the other half of the tank. The air is switched automatically by a special motor driven alternator device which can be timed for any desired period between alternations. In the average plant a period of about 30 sec. has been found to give good results.

It is said that the system requires less air than the old method and that the blocks freeze more quickly. One user of the new system is reported as saving 1½ hr. in freezing time.

Another feature of the system is the air tube which divides the flow at the bottom into two separate streams ejected into the water in opposite directions. A flexible rubber tube connects the lateral and tube with the air connection on the side of the lateral so that condensate may be drained from it without reaching the air tube nozzle. An elbow fitting attaches to the lateral and acts as an anchor holding the tube collar in position over the ice can with the hole in the collar, through which the elbow passes, sufficiently large to allow the tube a reasonable amount of swing in any direction. The method of support and attachment of the tube to the lateral permits it to swing in any vertical plane.

Coated Electrodes for for Steels

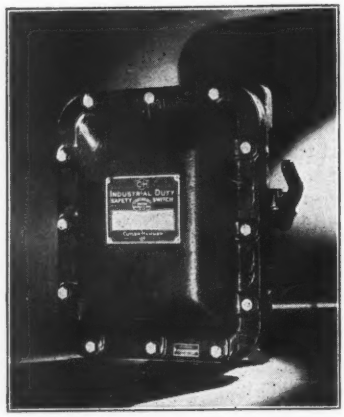
DIFFICULTY in arc welding steels containing more than 0.20 per cent carbon is reported to have been overcome by a new heavy coated electrode, known as "Murex Special A," developed by the Metal & Thermit Corp., New York City. The new electrode hinders the migration of carbon from the parent metal to the deposited metal when welding and assures a more ductile deposit. Sound, dense, X-ray-clean welds, having excellent penetration, can easily be made in high carbon steels with this new addition to the Murex line it is claimed. The deposit, containing a small quantity of nickel, has unusually good physical properties and stress-relieved, all weld metal specimens invariably show clean full-cupped fractures under test. The tensile strength of these deposits is 73,000 lb. per sq. in., the yield point 59,000 lb. per sq. in., the elongation in 2 in. is 31 per cent, and the reduction in area is 63.5 per cent.

Other recently developed Murex electrodes, designed for use with the latest high strength steels now make it possible to obtain welds with tensile strengths of 85,000 to 100,000 lb. per sq. in. Such high

strengths are obtained by including nickel or molybdenum, or a combination of these elements in the deposited metal.

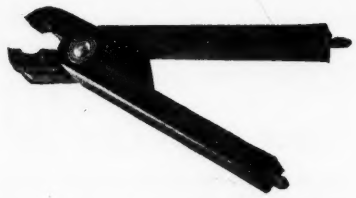
Explosion-Proof Safety Switches

NEW LINE of explosion proof safety switches for use in hazardous locations is announced, including both single throw and double throw types, in standard sizes up to 200 amperes capacity. Construction is heavy, industrial duty type with outside operating handle, mounted in a heavy weather-proof enclosure, complying with requirements of the National Electrical Code. Precision machined flange between the case and cover assures proper cooling of any flame which might occur from an explosion within the case. Two pipe-threaded conduit holes are provided in the bottom of the case and pads at the side and top of the case allow for drilling other holes if needed. Provisions are made for padlocking the handle with 3 padlocks in either position to meet specific industry requirements such as in steel mills. Bulletins descriptive of these switches will be sent on request, by the manufacturer, Cutler-Hammer, Inc., Milwaukee, Wisc.



Combination Test-Lite and Fuse-Puller

THE IDEAL COMMUTATOR DRESSER Co., Sycamore, Ill., has recently placed on the market a new tool for use in the electrical field—a combination "Test-Lite and Fuse Puller." Made of reinforced bakelite and like a pair of pliers, this new device is a combination tool for testing, removing or inserting fuses from 30 to 100 amp. capacity, testing circuits of from 110 to 550 volts, handling all types of "live" electrical parts, adjusting loose cut-out clips, etc.



Replacing both the ordinary fuse puller and the testing equipment usually employed, this new combination pocket tool really qualifies its description of "two tools in one." The test pins are mounted on handle ends—opening or closing handle adjusts pins to proper distance. Test light is enclosed in the handle. The tool's small pocket size—only 7 in. overall length—further adds to its convenience.

News From the Field

NINE OF THE nation's industrial leaders have been named to membership on the Advisory Committee of the American Standards Association, according to announcement by Howard Coonley, President of the Walworth Co., New York, and President of the Association. George B. Cortelyou, President, Consolidated Gas Co., who served as Postmaster General and later as Secretary of the Treasury, will be chairman of the Advisory Committee, other members of the Committee are: Sewell L. Avery, Chairman of the Board, Montgomery Ward & Company; President, U. S. Gypsum Co. Lammot duPont, President, E. I. duPont de Nemours & Company; Chairman, General Motors Corp. Walter B. Gifford, President, American Telephone and Telegraph Co. Henry I. Harriman, President, Chamber of Commerce of U. S. A. W. A. Irvin, President, U. S. Steel Corp. James H. McGraw, Chairman of the Board, McGraw-Hill Publishing Co. Gerard Swope, President, General Electric Co. Daniel Willard, President, Baltimore & Ohio Railroad.

THE JEFFREY MANUFACTURING Co. announces the appointment of Alphonse F. Brosky as special engineer attached to its general offices at Columbus, Ohio. To accept this new post Mr. Brosky has resigned as consulting editor of Coal Age, on the staff of which publication he had served in various editorial capacities from 1921 until the past winter when he acted as assistant fuel advisor to the Federal Surplus Relief Corporation in Washington.

JOHN E. BARKLE, general manager of the South Philadelphia Works of the Westinghouse Electric & Mfg. Co., age 53, died suddenly at his home in Swarthmore, Pa., on July 10. Born in Orbisonia, Pa., he was a graduate of Dickinson College and had been continuously in the service of Westinghouse for 33 yr.

THE AMERICAN SECTION of the Society of Chemical Industry announces the election of the following officers to serve for the year ending June 1, 1935: Chairman, Robert J. Moore; Vice Chairman, W. D. Turner; Hon. Secretary, Foster D. Snell; and Hon. Treasurer, J. W. H. Randall. In addition, five new members were elected to the Executive Committee to take the place of retiring members. Those newly elected are Lincoln T. Work, Wallace P. Cohoe, Albert E. Marshall, James G. Vail and Charles A. Lunn.

R. E. S. GEARE, formerly chief engineer, has been elected vice-president of the L. H. Gilmer Co., Philadelphia, Pa.

WILLIAM G. LE COMPTE, vice-president of Jenkins Bros., was recently commissioned colonel of the 107th regiment after 28 yr. service, beginning as a private when he came to New York, extending over service with his regiment in France and continuing since the war. The oath of office was administered by Alvin Reiff with Farnham Yardley, president of Jenkins Bros., as the appointed witness. Since his commission, Mr. Le Compte has been automatically retired from service by reaching the age limit.

STOCKHOLDERS' meeting of E. F. Houghton & Co., held on July 20, created the office of Chairman of the Board and Louis E. Murphy, formerly president, was elected to that position. Mr. Murphy has been with the company 44 yr., as secretary from the time of its incorporation until elected vice-president in 1914, and in the latter office until he was elected president in 1929, following the death of Charles E. Carpenter.

Major Aaron E. Carpenter, who was elected President and General Manager, has been with the company 29 yr. as a member of the original board, and as treasurer from 1921 to 1929, when he became first vice-president. He is the third generation of Carpenters to occupy the presidency of E. F. Houghton & Co.

Other officers elected were: George W. Pressell, Vice-President and Director of Sales; A. Everly Carpenter III, Secretary; Dr. R. H. Patch, Treasurer; C. P. Stocke, Assistant Secretary; Miss M. M. Menningen, Assistant Treasurer. Also the Board of Directors was increased to seven members, the following being elected: Louis E. Murphy, Major Aaron E. Carpenter, George W. Pressell, A. Everly Carpenter, III, Dr. R. H. Patch, Herbert B. Fox, C. Howard Butler.

WESTINGHOUSE Electric & Mfg. Co. shows, in its report for the second quarter of 1934, encouraging improvement of business. Sixty-six per cent increase in orders over the first quarter and 91 per cent over the second quarter of 1933. Fifty-one per cent increase in sales billed over the first quarter and 71 per cent over the second quarter for 1933. Profit of $1,744,427 was shown as against loss of $1,716,152 for the first quarter and loss of $2,078,424 for the second quarter of 1933. For 6 mo. of 1934, net loss was $31,725 as against net loss of $5,569,996 for 6 mo. of 1933.

AT A RECENT meeting of the Board of Directors of A. M. Byers Co. M. J. Czarniecki, formerly General Manager of Sales, was elected Vice President in charge of sales, succeeding H. W. Rinearson, resigned.

ANNOUNCEMENT HAS just been made that the Ford Motor Co. has ordered a second 110,000 kw. vertical compound turbine generator for the River Rouge power plant. This machine which is being furnished by the General Electric Co. is to be similar to the vertical compound generating unit installed in the same plant in 1930. The new unit, however, will incorporate several new features, one of which is that it will operate at 1200 lb. pressure and at an initial steam temperature of 900 deg. F. This will be the first large unit in the world to operate at that temperature and pressure. In addition to this large unit, the General Electric Co. is also furnishing a 15,000 kw. non-condensing turbine for installation in the same station. This will furnish process steam to the Ford factory at 250 lb. pressure.

The new unit will be rated at 110,000 kw. 80 per cent power factor, 13,800 v., 1800 r.p.m., 3 phase, 60 cycles with steam conditions of 1200 lb. gage pressure, 900 deg. F. with one inch abs. back pressure. The high and low pressure units will each be rated at 55,000 kw.

General dimensions are as follows: overall length, 57 ft. 6 in.; width, 23 ft.; height, 21 ft. above floor. The approximate weight will be 2,000,000 lb. In terms of floor space the unit will occupy less than a quarter of a cubic foot per kilowatt of output.

CONTRACTS for the boiler and superheater drums and appurtenances for the cruisers Brooklyn and Philadelphia have been awarded to Combustion Engineering Co., Inc., by the U. S. Navy Department. The contract includes 64 welded drums and contains an option for similar equipment for one, two or three additional vessels. These vessels are being constructed at the Brooklyn and the Philadelphia Navy Yards respectively, and the boilers will be built at the Yards.

AT THE RECENT meeting of the Smoke Prevention Association, the following officers were elected to serve for the ensuing year: President, Frank Trumble, Smoke Inspector, Buffalo; first vice-president, W. E. E. Koepler, Secretary, Pocahontas Operators Assn., Bluefield, W. Va.; second vice-president, William Langlands, Master Mechanic, Chicago & North Western R. R. Co., Chicago; secretary-treasurer, F. A. Chambers, Chief Smoke Inspector, City of Chicago, Chicago, Ill.; sergeant-at-arms, H. V. Carlson, traveling fireman, Nickel Plate R. R., Chicago, Ill.

For the Engineer's Library

A TEXT BOOK OF APPLIED HYDRAULICS. By Herbert Addison. First Edition. Size 6 by 9 in. Cloth, 409 pages, illustrated. John Wiley & Sons, Inc., New York, 1934. Price, $5.50.

This seems to be a very understandable book on the subject of hydraulics, one not too complex for the non-specialist and yet not too simple as to be impractical for actual use in the field. As a matter of fact the book is designed largely for the non-specialist, though not entirely so.

The author is a professor at the Royal School of Engineering at Giza, Egypt, and as such has an excellent knowledge of the requirements of the general student of engineering in this field. For a number of years he has been trying in the lecture room and in the laboratory to make clear the principles of hydraulics and his success in these endeavors are reflected in this volume.

One type of reader has been particularly kept in mind, that is the man whose work is not directly connected with hydraulics but who requires to be kept in touch with the main outlines of hydraulic practice, such as the electrical engineer for example. For his benefit the book is conveniently divided into two parts so that when used as a work of reference only the second part dealing with practical application as a rule need be consulted.

A number of worked out examples form a valuable part of the book. In these examples, and also in the text, Imperial (foot, pound) units and metric units have been used side by side; even readers whose work is not connected with countries using the metric system may find it advantageous to be able to think in terms of liters per second and of kilograms per square centimeter. A comprehensive table of conversion factors is given at the end of the book. The book is well illustrated by numerous diagrams and a number of half tone plates.

APPLICATIONS of Monel Metal, Nickel, and Nickel-clad steel are enumerated in a new booklet issued by the Technical Service Department of The International Nickel Co., New York City. It has been prepared especially for users of industrial processing equipment. Besides giving data on the physical and mechanical properties of these materials, the booklet contains considerable miscellaneous information, including instructions on the selection of suitable welding rod and other details on fabrication.

THE SHIELDED ARC and its performance are described in a new 12-page catalog issued by Lincoln Electric Co. of Cleveland, Ohio.

D. O. JAMES MFG. CO., Chicago, Ill., has issued its catalog No. 137, entitled "Continuous-Tooth Herringbone Speed Reducers and Gears" which describes and illustrates all the various designs and patterns of these devices made by the company and also gives weights and dimensions of the various sizes manufactured.

MCCLAVE-BROOKS CO., Scranton, Pa., describes its type SR underfeed stokers in a pamphlet just issued.

WORTHINGTON PUMP & MACH'Y CORP., Harrison, N. J., has issued two bulletins of interest to power plant readers. One deals with Worthington Diesel engines of the vertical 4 cycle direct injection type. The other is devoted to Worthington centrifugal pumps of the single stage volute type. These bulletins contain condensed descriptions of this equipment, giving features of design and construction which every engineer is interested in knowing.

BOOSTER COMPRESSORS for use in plants where steam is required at higher pressure and temperature than the existing boiler installation can supply, are described in a four-page pamphlet issued by the Worthington Pump & Machinery Corp., Harrison, N. J.

HAGAN CORP., Pittsburgh, Pa., has just issued a bulletin under the title, "Portable Compressed Air Cleaner." This new device has for its purpose the removing of all moisture, oil and dirt from compressed air which is used for blowing dust and dirt accumulations from motors, generators, switchboards, engines, etc.

"THE WORLD'S MOST Popular Pneumatic Tools," is the title of bulletin 2037-A recently issued by Ingersoll-Rand Co., New York City. It deals with drills, grinders, riveters, hammers, wrenches and hoists, giving the necessary data for selecting tools for the services anticipated.

THE BORDEN CO., Warren, O., has issued its bulletin Form 634, which describes a variety of pipe working tools including both hand and electric drive. Among these are the Beaver pipe reamer and Nos. 70 and 72 series die stocks which are entirely new equipment developed by this company.

EXPERIENCE in Salary Standardization for large companies is given in a report issued by Policyholders Service of the Metropolitan Life Ins. Co. of New York City, showing methods used, basis of control and classification of jobs.

JOHNS-MANVILLE, New York City, describes in a new 48-page catalog over 60 different types of packing manufactured by this company. These packings are not only described but shown in large illustrations and the catalog includes a complete table of recommendations showing the type of packing best suited for each requirement. A section is also devoted to a discussion of methods of installing packings and the factors upon which satisfactory results mainly depend.

CARNEGIE STEEL CO., Pittsburgh, Pa., has just issued a bulletin under the title "I-Beam-Lok Armored Bridge Roadway Slabs and Heavy Duty Floors." The bulletin contains a description of these floors and a great amount of technical data relative to their use in industry.

FOUR CYCLE, direct injection Diesel engines, Types B, C, D and E, manufactured by Worthington Pump & Machinery Corp., Harrison, N. J., are described in a new bulletin recently issued by that company. The bulletin covers engines from 25 to 600 hp. in 2 to 8 cylinder units. Larger engines up to 1000 hp. are covered in a special bulletin.

MAINTENANCE of Reciprocating Parts is the title of a new 8-page booklet issued by Linde Air Products Co., New York, N. Y., dealing with application of bronze to sliding surfaces by the oxy-acetylene process of welding.

TROY ENGINE & MACHINE CO., Troy, Pa., has just issued a new bulletin describing Troy-Engberg generating units particularly adapted for marine and stationary, direct and alternating current use, the drive being vertical and horizontal Troy-Engberg steam engines.

SHAFER SELF-ALIGNING Roller Bearing Units is the title of Catalog No. 12 just issued by Shafer Bearing Corp., Chicago, Ill., describing a complete line of roller bearing units for a wide variety of industrial and machine applications.

SIX recently issued publications of the De La Vergne Engine Co., Philadelphia, are Nos. 51 to 55 incl., and No. 58, descriptive of the full line of De La Vergne Diesel engines. These are all four-cycle, full Diesel, solid injection, ranging from Model VL with six cylinders which, at 1200 r.p.m., develops 200 hp., up to the Model VB which with eight cylinders at 200 r.p.m. develops 1600 hp. Copies of the booklets are available on request.

HAYS instruments, including combustion recorders, gas analyzers, draft gages and boiler panels are interestingly described and illustrated in a 32-page catalog issued by The Hays Corp. of Michigan City, Ind.

Power Plant Construction News

Calif., Los Angeles—McCloskey Varnish Co., Rhawn Street and State Road, Philadelphia, Pa., plans installation of electric power equipment in new branch technical paint manufacturing plant at Maywood, near Los Angeles, where tract of land has been purchased. Cost about $150,000.

Calif., Sacramento—Sacramento Irrigation District, Albert Given, chief engineer, is considering construction of new public-owned central generating plant, power substations, transmission and distribution lines for electric power service in Sacramento Valley district. A report on project is being made by Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., consulting engineer. Cost reported over $12,000,000.

Calif., San Diego—Board of Public Works, City Hall, City Manager Lockwood, in charge, is considering construction of new municipal electric light and power plant, using Diesel engine-generating units, for street-lighting and other municipal service. Estimated cost $150,000.

Calif., San Francisco—Standard Oil Co. of California, 225 Bush Street, plans installation of group of five main pumping plants for operation of proposed new welded steel pipe line from oil field district, Kern County, to oil terminal at Estero Bay, San Luis Obispo County, about 105 miles, for crude oil transmission. Cost about $3,000,000. Company engineering department will be in charge.

Colo., Gunnison—Board of Trustees, Western State College, plans new steam power plant at institution for central heating service, to include two 280-hp. boiler units, with stokers, pulverizers and complete auxiliary equipment. Cost about $50,000. Prouty Brothers Engineering Co., Exchange Building, Denver, Colo., is consulting engineer.

Colo., Summitville—Summitville Consolidated Mines, Inc., plans installation of electric power equipment in connection with new ore-treating mill. Cost over $65,000. Electric service will be furnished by Public Service Co. of Colorado, Denver, which will build new transmission line from Alamosa, Colo., to plant site for this purpose, with construction of local power substation.

Conn., Modus—Haddam Distillers Corporation plans installation of electric power equipment in connection with extensions and improvements in distilling plant. Financing is being arranged for $288,750, large part of fund to be used in this program. David L. Nair, New Britain, Conn., is treasurer.

D. C., Washington—Bureau of Yards and Docks, Navy Department, will receive bids until Oct. 3 for two new power substations and electrical distribution system at Navy Yard, Pearl Harbor, T. H., including motor-generator sets with automatic control, transformers and accessories, new underground conduit system, etc. (Specification 7604).

Fla., Jacksonville—Merchants & Miners Transportation Co., has approved plans for new precooling and refrigerating plant at local waterfront terminal, and will proceed with work at early date. Cost close to $40,000.

Fla., Pensacola—Gulf Industries, Inc., Thomas S. Connbrook, executive vice-president, plans installation of electric power equipment in proposed new shipbuilding and repair plant on waterfront, where tract of 180 acres of land is being secured from city. A boiler plant will be built. Entire project will cost close to $2,500,000, including drydock units. Financing is being arranged. Frederick Gillimore, Sr., is president.

Fla., St. Augustine—City Commission will soon have surveys and estimates of cost made for proposed municipal electric light and power plant, including construction of transmission line to Jacksonville, Fla., and appraisal of local property of Florida Light & Power Co. An engineer will be selected early in September.

Md., Baltimore—Chevrolet Motor Co., 3044 West Grand Boulevard, Detroit, Mich., plans installation of electric power equipment in new automobile assembling plant on 45-acre tract of land in Canton district, Baltimore, consisting of several units, of which one or more will be occupied by Fisher Body Co., Detroit, an affiliated organization. Entire project will cost close to $450,000. Albert Kahn, Inc., New Center Building, Detroit, is architect and engineer.

Mich., Kalamazoo—Upjohn Co., plans construction of new steam power plant, 46 x 53 ft., in connection with expansion program at drug products and pharmaceutical factory, to include new six-story manufacturing plant, 70 x 250 ft., to be equipped for electric operation, and new office structure. Entire project will cost over $400,000. Albert Kahn, Inc., New Center Building, Detroit, Mich., is architect and engineer.

Mich., Wyandotte—Marx Brewery Co., plans installation of electric power equipment in connection with expansion and improvements at brewing plant for increased production. Cost over $70,000.

Minn., Minneapolis—Hiawatha Brewing Co., Hiawatha Avenue and Thirty-first Street, plans installation of electric power equipment in connection with extensions and improvements in brewery, including new mechanical bottling works. Company is arranging financing for $200,000, considerable portion of fund to be used for program noted. Helmar Knudsen is president.

Minn., Worthington—Common Council plans early call for bids for new turbo-generator unit and accessory equipment for municipal electric light and power plant. Financing has been arranged. Charles Foster, Sellwood Building, Duluth, Minn., is consulting engineer.

Mo., Perry—Common Council has plans nearing completion for new municipal electric light and power plant. Cost about $64,000. W. B. Rollins & Co., Railway Exchange Building, Kansas City, Mo., are consulting engineers.

N. J., Phillipsburg—J. T. Baker Chemical Co., plans early construction of one-story boiler plant for factory service. Cost about $45,000, with equipment. J. G. Berger, 24 Commerce Street, Newark, N. J., is consulting engineer.

N. J., South Amboy—American Agricultural Chemical Co., 420 Lexington Avenue, New York, N. Y., will completely electrify its proposed new commercial fertilizer and phosphate plant on tract of waterfront land recently acquired at South Amboy. Plant will consist of several units, estimated to cost close to $300,000. Dr. R. L. Sebastian is chief chemical engineer.

N. Y., Conesus—O-Neh-Da Vineyard & Distillery, Inc., plans installation of electric power equipment in connection with extensions and improvements in local distilling plant. Financing is being arranged for $390,000, portion of fund to be used for purpose noted.

N. C., Bryson City—Nantahala Power & Light Co., Bryson City, plans new transmission line in different parts of Macon County, with power substation facilities for service along route. Company engineering department is in charge. Application for permission has been made.

Ohio, Cleveland—Fisher Body Corporation, General Motors Building, Detroit, Mich., manufacturer of automobile bodies, plans installation of electric power equipment in new one-story addition, 200 x 400 ft., to branch plant at Coit Road and East 140th Street, Cleveland. Entire project will cost close to $150,000.

Ohio, Wapakoneta—Common Council will soon have plans drawn for new municipal electric light and power plant. Fund of $146,000 has been secured through Federal aid for project.

Ohio, Warren—Middletown Distilling Corporation, 1103 Mahoning Bank Building, Youngstown, Ohio, recently organized, plans installation of electric power equipment in proposed new distillery on Youngstown Road, Warren, where plant of Western Reserve Brewing Co. has been acquired, and will be remodeled and equipped for new service. Cost over $100,000. Charles Owsley, Home Savings Bank Building, Youngstown, is architect.

Texas, Littlefield—Common Council plans installation of oil engine-generator unit and accessory equipment, electric pumping machinery and auxiliaries, and construction of 6000-volt transmission line, for new municipal waterworks. Fund of $48,000 is being arranged. H. N. Robert, Lubbock, Texas, is consulting engineer.

Texas, Pecos—Red Bluff Water Power Control District is considering new hydroelectric generating plant on Pecos River, Reeves County, Texas, with transmission lines to neighboring points, power substations and switching stations. Cost reported over $250,000. Application has been made for permission.

Va., West Point—Albemarle-Chesapeake Co., and Chesapeake Corporation, affiliated interests, manufacturers of kraft paper stocks, etc., plan installation of electric power equipment in connection with extensions and improvements at mills for increased output. Cost over $250,000.

Wash., Seattle—Hemrich Brewing Co., 5225 East Marginal Way, plans installation of electric power equipment in new two-story and basement addition, 75 x 150 ft., to be used for mechanical bottling and other service. Cost about $85,000, with machinery.

Wis., Stoughton—City Council has plans maturing for new addition to municipal electric light and power plant, including installation of new generator unit and auxiliary equipment. Cost close to $100,000. Power Engineering Co., Metropolitan Life Building, Minneapolis, Minn., is consulting engineer.